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EDITORIAL NOTES.

THE Committee on British Petrographic Nomenclature that has been sitting for some months has now issued its report, which has been printed in the *Mineralogical Magazine*, and a separate copy has also been issued to every one entitled to receive No. 305 of the *Quarterly Journal of the Geological Society*. We should like to take this opportunity of congratulating the committee, and especially the chairman, Professor Watts, and the secretary, Mr. W. Campbell Smith, on this prompt appearance of the results of their labours. An additional number of copies of the Report are still available for distribution, first to petrologists abroad and then to any interested persons who may apply for them to the Secretary. It is not proposed here to offer any detailed remarks on the subject-matter of the Report, except to say that in our opinion a very wise course has been followed in suggesting the discontinuance of a considerable number of obsolete, ambiguous, and unnecessary names. In this respect the Committee might even with advantage have gone further than it has. At all events, it is satisfactory to find that the Committee is not to be dissolved, as we believe that a good deal of useful work may yet be accomplished by it in the direction of the simplification of a science hitherto overburdened and rendered unattractive by a ponderous nomenclature. It is hoped that some further comments on this subject, editorial and otherwise, will appear in a later issue.

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THE Secretary for Mines has appointed Dr. F. H. Hatch, M.Inst.C.E., M.Inst.M.M., to be Technical Adviser to the Mines Department on questions relating to the Metalliferous Mining Industry.

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ORIGINAL ARTICLES.

On Cycles of Sedimentation in the Eocene Strata of the Anglo-Franco-Belgian Basin.

By L. Dudley Stamp, M.Sc., A.K.C., F.G.S., King's College, London.

(*Concluded from p. 157.*)

C. The London "Basin".

Landenian.—The Landenian is represented by the Thanet Sands and Woolwich and Reading Beds. The former seem to correspond to the two lower zones of the French Landenian, whilst the marine Bottom Bed of the Woolwich Series corresponds to the zone of *Cyprina scutellaria*. The present writer has given reasons for believing the pebble-bed separating the two to be due to a movement of uplift in the Wealden area.[1] In the east of the London district the marine Bottom Bed passes up into clays and marls crowded with estuarine fossils (Woolwich Beds); to the west into unfossiliferous mottled clays and fluviatile sands (Reading Beds). The extensive transgression at the time of the zone of *Cyprina scutellaria* is noticeable in the London Basin as it is in the Paris and Hampshire Basins.

Ypresian.—The Ypresian commences with the Oldhaven or Blackheath Beds. A slight upward movement of the Weald caused the sea to spread rapidly over the Upper Landenian estuarine flats, and at the same time great masses of pebbles tended to move from the northern flank of the Weald into the same area. In this disturbed marine region the invading Ypresian species lived side by side for a short time with the existing estuarine species of the lagoons, and so gave rise to the mixed Blackheath fauna. Continued transgression and more tranquil conditions resulted in the formation of the Basement Bed of the London Clay. The clay itself is much thicker in the east than in the west, and passes up gradually into sandy beds (Claygate Beds), and then into the continental Bagshot Sands. The latter are thicker in the west, and, as Mr. Whitaker showed many years ago, overlap the marine Ypresian, and come to rest on the continental Landenian, or even on the Chalk.[2] The London Clay is only 15 feet thick at Great Bedwin in the extreme west, about 50 to 60 feet at Newbury, but increases rapidly to over 400 feet in the North of London and about 490 feet in the Isle of Sheppey. In the London district it thins off rapidly southwards against the Wealden Dome. This is another proof that the Weald was being uplifted during Eocene times.

[1] Stamp and Priest, "Geology of the Swanscombe Eocene Outlier": *Proc. Geol. Assoc.*, vol. xxxi, 1920, p. 191.

[2] Whitaker, "On the Western End of the London Basin": *Quart. Journ. Geol. Soc.*, vol. xviii, 1862, p. 258.

Lutetian.—The beds above the Ypresian in the London Basin occur in a somewhat limited area—the Bagshot District of Surrey and Berkshire. The marine Lutetian is represented by glauconitic clayey sands, etc., in which *Nummulites lævigatus* has been found. These are the Bracklesham Beds of the Survey and recent authors. The Lutetian thickens eastwards from about 30 feet near Ascot to about 100 feet on St. George's Hill, near Weybridge. The upper part indicates shallower-water conditions.

Ledian or Bartonian.—The "Upper Bagshot Sands" (now usually called Barton Sands) of the London Basin comprise a series of sands over 200 feet in thickness with a very persistent and well-defined pebble-bed at the base. Marine fossils poorly preserved are found locally, and the fauna is generally considered as indicating a Lower Barton age. If that is so the Ledian is absent from the London Basin. Although "*Nummulites elegans*" (? = *N. Prestwichii*) was recorded by Prestwich himself in 1847 [1] he seems to have favoured the correlation of these "Upper Bagshot Sands" with the Upper Bracklesham or Ledian.[2] A careful search for *Nummulites* in the ironstones should settle this question.[3]

D. The Belgian "Basin".

In many ways the Eocene strata in Belgium and North France differ from those in other parts of the Basin. Above the Landenian the succession is almost, if not entirely, marine. This is due, doubtless, to the absence of rivers bringing sediment from the east. At the same time the Palæozoic floor in Belgium is found at no great depth, and parts of it projected to form islands or rocky submerged shoals in the Eocene sea. This is particularly noticeable in the case of the Diorite masses of Quenast, etc., round which one finds conglomeratic beds of Landenian or Ypresian age. It is well to bear this fact in mind in considering the distribution of the deposits known as "Paniselian".

The beds can be grouped in the same six cycles as in other parts of the Basin. The succession has naturally often been compared with that in the Paris region, and the correlation is now well established. For that reason the diagram (Fig. 4) has been drawn to show the connexion with the London Basin.

Montian.—As in the Paris Basin, the Montian deposits are of restricted occurrence, being found principally in the "Bassin de Mons". The "Bassin de Mons" is a synclinal region running from west to east. It is partly an original basin of deposition, and must have formed a gulf-like inlet from the west. The Eocene rocks now form a very pronounced syncline due to later folding. The marine Montian consists of the famous Calcaire grossier de Mons—a very fossiliferous soft limestone—which, unfortunately, is rarely visible.

[1] Prestwich, *Quart. Journ. Geol. Soc.*, vol. iii, 1847, p. 393.
[2] Prestwich (in discussion), ibid., vol. xxxix, 1883, p. 354.
[3] White records *N. variolarius*, op. cit., 1917, p. 270 (*Handb. Reg. Geol.*).

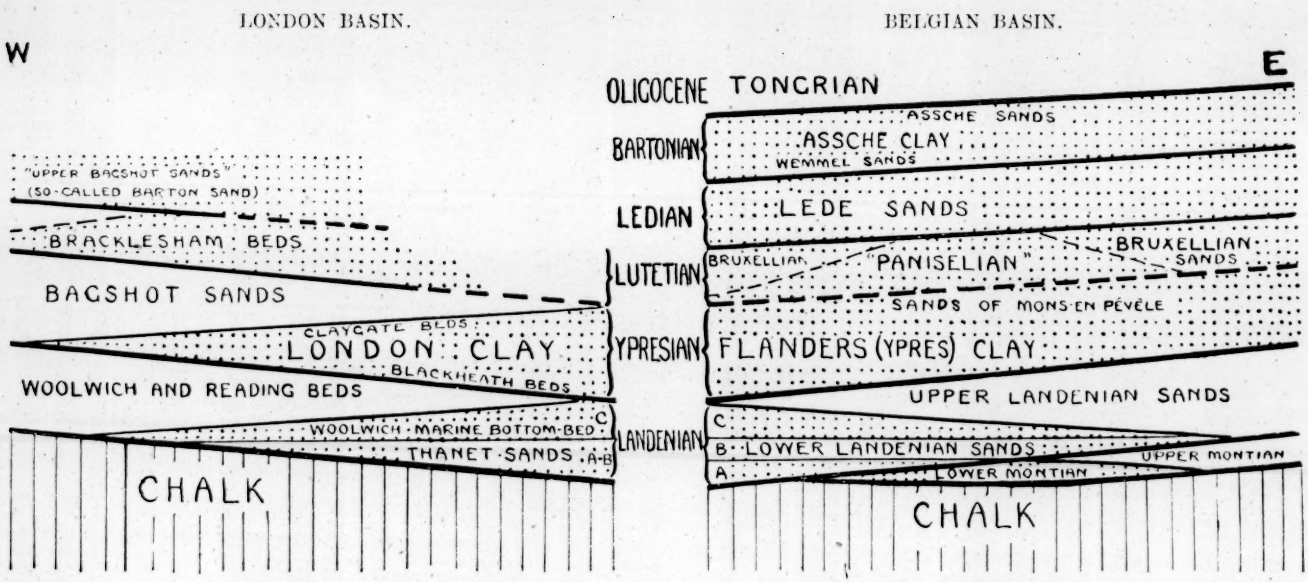

FIG. 4.—Cycles of sedimentation—London and Belgian Basins. Landenian Zones: A = zone of *Cyprina Morrisi*; B = zone of *Pholadomya Koninckii*; C = zone of *Cyprina scutellaria*.

The Tuffeau de Ciply is a sparingly fossiliferous lateral phase of the same bed, and is exposed in several places to the south of Mons. The continental Montian thickens eastwards from Mons, and consists of dark lagoon clays, fluviatile sands, and lacustrine limestones, with *Chara* and *Physa*.

Landenian.—The Landenian consists chiefly of glauconitic sands, with some harder beds—calcareous or siliceous—of "tuffeau", especially at the base. It can be separated into the same zones as in France, and the three zones demonstrate a marked transgression.

During the time of deposition of the sediments of the zone of *Cyprina Morrisi* there seems to have existed in Eastern Belgium (Hesbaye) an isolated basin or tranquil gulf. In this area was laid down a basal sand (Sable d'Orp-le-Grand) followed by a considerable thickness of white chalky marl (Marne de Gelinden) with *Cyprina Morrisi* and numerous well-preserved plant remains. This is the "Heersian" of the older Belgian writers. The waters of the main Anglo-Franco-Belgian Basin invaded this area at a later date, and one finds the tuffeau with *Pholadomya Koninckı* resting irregularly on the Marne de Gelinden.

The marine Landenian sands become less glauconitic in the upper part and frequently pass up into false-bedded and lignitiferous fluviatile sands. As one approaches the Ardennes one finds that these continental deposits occur as narrow bands filling river channels in the marine beds or even in the Chalk. As a rule the streams seem to have flowed from south-east to north-west, and point to a small quantity of sediment having been derived from this direction. As one would expect, the continental Landenian is of very local occurrence. Towards the north-west, as borings in the neighbourhood of Ostend have shown, estuarine clays of Woolwich type are present.

Ypresian.—As in the London Basin the Ypresian consists of a thick mass of clay (Argile des Flandres). There is a thin sandy basement bed and a line of pebbles at the base. The clay passes up into a very fine sand with *Nummulites planulatus—elegans* (Sables de Mons-en-Pévèle). Traced eastwards the clay grades laterally into more sandy littoral beds. The character of the latter demonstrates the tranquil conditions prevailing along the eastern shore of the basin. More to the north-west in the Flanders plain the main mass of the Ypresian clay passes up into sandy clays with beds of very fine sand, followed by more clay. Then follows a series of coarse glauconitic sands—the "Paniselian". For the French geologists the "Paniselian" commences with the coarse sands (Paniselian of Cassel), but the Belgian geologists include the sandy clays and fine sands below in this stage. The coarse glauconitic sands which make up the bulk of the "Paniselian" occupy the higher parts of the hills from Cassel, in France, to the River Senne, north and south of Brussels. Over a considerable portion of this area there is a thin band of clay at the base. This is the *P* 1 *m* of the Belgian Geological Survey.

Lutetian.—There are good reasons for believing that the "Paniselian" is a local shallow-water representative of the lower part of the Lutetian. Its fossils on the whole seem to be intermediate between those of the Ypresian and the normal Lutetian. To the west, in the hills of Cassel and Mont des Recollets, it passes up gradually by loss of glauconite into the "Bruxellian" sands. The latter have the fauna of the lowest zone of the Lutetian—the zone of *Maretia Omaliusi*. As one goes westwards there is still a gradual passage from the "Paniselian" into the paler and more calcareous Bruxellian sands, but the latter become very thin, being only a foot or two in thickness at Mont Aigu, and are absent at Mont Kemmel.[1] It appears, then, that the "Paniselian" is a facies of the lower part of the Lutetian, deposited in a shallow sea stretching eastwards as far as Brussels. East of Brussels one has again the "Bruxellian"—siliceous or calcareous sands—of the age of the lowest zone of the Lutetian. Possibly the Lutetian sea transgressed from the north towards the Paris area, so that the "Bruxellian" deposits are slightly earlier in age than the zone of *Maretia Omaliusi* in the Paris Basin. In any case all the Bruxellian deposits are earlier than the zone of *Nummulites lævigatus*, except in the extreme west at Cassel, where the zonal fossil occurs in the higher part of the "Bruxellian" sands.

Further work on the "Paniselian" is very necessary, and the junction between the "Paniselian" and the Ypresian is still uncertain.

Ledian.—The Lutetian deposits must have been very considerably denuded before the deposition of the Ledian. Although the Lutetian zone of *Nummulites lævigatus* is nowhere found *in situ* in Belgium, this Nummulite occurs in enormous numbers, associated with other Lutetian fossils, in a rolled condition in the basal conglomerate of the Ledian. The Ledian consists of fine whitish sands, characterized by the presence of *Nummulites variolarius*.

Bartonian.—The Bartonian consists mainly of a grey glauconitic clay—the Argile d'Assche. Locally there are beds of sand at the base. These are the "Wemmelian" or Wemmel Sands, and they contain *Nummulites Orbignyi* Gal.—*wemmelensis* De la Harpe. Where they are absent the basal bed of the "Asschian" is formed by a sand extremely rich in glauconite and known as the "Bande noire". The Assche Clay passes up into sands with *Nummulites wemmelensis*.

They are succeeded by the Oligocene (Tongrian), of which the base does not always seem to be very clearly defined.

[1] Stamp, "Note sur la Géologie du Mont Aigu et du Mont Kemmel": *Ann. Soc. géol. Nord*, vol. xliv, 1919, p. 115.

IV. NOMENCLATURE.

It may be useful to give here some reasons for the general names adopted for the cycles.[1]

Landenian (Dumont, 1839, defined by Meugy, 1852).—The inapplicability of the terms Thanetian and Sparnacian have been mentioned above.[2]

Ypresian (Dumont, 1849).—The term Londinian of Mayer-Eymar (1858) is bad, since he confused the London Clay and Woolwich Beds. Also confusion with Landenian in inevitable. Dollfus prefers his own term Cuisian (1880), on the grounds that Cuise is a more fossiliferous locality, and that neither stratigraphy nor palæontology is to be observed at Ypres. On the contrary, Ypres is a typical locality in that the beds are of the familiar argillaceous type, common to the Hampshire, London, and Belgian regions (London Clay). At Marck, not very from far Ypres, Leriche has shown that the argillaceous sediments occur interbedded in certain localities with sands of Cuise type, and that the faunas of the London Clay and Cuise Sands occur in alternating layers. Moreover, fossiliferous horizons of London Clay species have recently been found in the Flanders plain round Ypres.

Lutetian (de Lapparent, 1883) is generally accepted.

Ledian (Mourlon & Vincent, 1887) was originally applied in Belgium to the beds with *Nummulites variolarius*. Auversian (Dollfus, 1880) was originally far more restricted in meaning.

Bartonian (Mayer-Eymar, 1858).—Although a much misused term, the Barton sequence is a very good one to take as a type.

V. CONCLUSION.

This paper is a brief resumé of the results of several years field work on the Tertiary deposits. For the sake of brevity, references have been confined to a few special points. The author regrets that it is impossible, for the same reason, to acknowledge individually his indebtedness to a large number of friends both on the Continent and in England. Without their cordial assistance the work would have been impossible.

Part of the expense of this investigation has been defrayed by a grant from the Dixon Fund of the University of London, and by the Layton Research Studentship of King's College (University of London).

Postscript.—(1) Belgian geologists have recently come to the conclusion that the Tuffeau de Ciply is not a lateral phase of the Calcaire de Mons, but is earlier (Danian) in age.

[1] Compare also Leriche, "Observations sur la Classification des Assises paléocènes et éocènes du Bassin de Paris": *Ann. Soc. géol. Nord*, vol. xxxiv, 1905, p. 383. Dollfus, "On the Classification of the Beds of the Paris Basin": *Proc. Geol. Assoc.*, vol. xxi, 1909, p. 101. Lemoine, *Géologie du Bassin de Paris*, 1911, p. 198 et seq.

[2] See also Leriche, "Sur la signification des termes Landenien et Thanetien": *Ann. Soc. géol. Nord*, vol. xxxiv, 1905, p. 201.

(2) The Paniselian is sometimes regarded as having been formed in *deeper* water than the Bruxellian.

(3) Recent study of the fauna seems to show that the fossiliferous horizon in the Flanders Clay at Bailleu, Ploegsteert (near Messines), etc., marks the base of the Lutetianl (Paniselian facies), and that the Belgian geologists have been correct in regarding the series of sandy clays in the higher part of the "Argile des Flandres" as Paniselian.

The Boulders of the Travellers' Rest Gravel Pit, Cambridge.

By J. E. A. Wheeller, Christ's College, Cambridge.

ABOUT twelve years ago Dr. R. H. Rastall and Mr. J. Romanes published an account of the Boulders of the Cambridge Drift.[1] In this paper a list was given of the rock-types recognized at that time in the gravels of the Travellers' Rest Pit, situated about a mile north-west of the town of Cambridge on the Huntingdon Road. Since that time Professor Marr has paid much attention to this pit, among others, with special reference to the Palæolithic implements there found. He has embodied his results in two important papers.[2] In the course of this work Professor Marr collected a number of interesting erratics, and the same pit has also been investigated by many geologists connected with the University, both members of the Sedgwick Club and others. During the last ten years, though the North Pit has been abandoned, the South Pit has been very actively worked for gravel, and has been greatly increased in size. In consequence of this a large amount of additional material has been collected, including many new types, while some of the older specimens, whose origin had been left indeterminate by Rastall and Romanes, have been now identified. Hence it is felt that the time has now arrived when these more recent results should be put on record.

The Travellers' Rest Pit is excavated in the "Gravels of the Ancient River System" of the earlier literature. It is not proposed here to discuss its stratigraphical relations. On this point reference may be made to Professor Marr's recent publications, especially to the *Q.J.G.S.* paper, in which a sketch is given of the "face" of the pit. It is intended in this paper only to deal with the erratics found in the gravels.

The list given by Rastall and Romanes in their paper is as follows:—

Carboniferous Limestone, several, some striated.
Millstone Grit, several.
Basalts, Dolerites } large and unusually well rounded.

[1] *Quart. Journ. Geol. Soc.*, vol. lxv, 1909, p. 246, et seq.

[2] *Quart. Journ. Geol. Soc.*, vol. lxxv, 1919, p. 204, et seq.; and *Proc. Camb. Phil. Soc.*, vol. xix, 1917, p. 64.

Rhomb-porphyry (2).
(?)Nordmarkite.
Pink granulitic granite, two large specimens.
Orthophyre of North Berwick type.
(?)Analcime-dolerite (Teschenite) of Forth Valley type.
Cheviot porphyrite and lava.
Coarse white granite.
Large concretion with *Serpula tetragona*.
A species of *Gryphæa*, intermediate between *arcuata* and *dilatata*.

To proceed to a detailed description of the new types recorded. The specimens may be classified according to their reputed source of origin, which sources may be conveniently divided as follows:—

1. Scandinavia.
2. Scotland and Scottish borders.
3. Lake District.
4. North-Eastern and Eastern England.
5. Source unknown.

Of necessity the majority of specimens are allocated to the last class.

To deal with the divisions severally, commencing with the Scandinavian types. The only specimens which had been recorded at the time of publication of Rastall and Romanes' paper, were rhomb porphyry and a doubtful nordmarkite, or, rather, I should say, these were the only certain types. Since that time several more specimens of rhomb porphyry have been collected, notably by Professor Marr, one of which is remarkably large, measuring 12 by 11 by 7 inches. This rock, however, is far from common at the Travellers' Rest Pit, though it is found in greater abundance elsewhere in the Cambridge district. Laurvikite, which has been recorded from the district before, has been collected at the pit, once only I believe, and that specimen a small and badly weathered one. One small specimen of the pink soda granite of Christiania has been collected.

Perhaps the most important discovery from the pit, however, is a small boulder with a violet-brown groundmass, in which are scattered grains of quartz, small orthoclase felspars, and greenish plagioclase. This corresponds therefore very closely with the Särna porphyry, according to Milthers'[1] description of that rock. A second specimen has recently been collected bearing a strong resemblance to the last, but with a smaller amount of quartz and without plagioclase, so far as can be seen by the naked eye. The groundmass also is dark grey, rather than violet-brown. This strongly resembles the specimens of the Elfdal porphyry in the Natural History Museum. These rocks therefore belong to the Dala group of porphyries, as described by Milthers, a type not hitherto recognized in this neighbourhood. On looking through the collection

[1] Milthers, *Indicator Boulders*, D.G.U. II, R. Nr. 23, Copenhagen, 1909; and Geschiebe aus der Umgegend von Königsberg in Ostpreussen, Phys.ök. Gesell. zu Königsberg, 1888.

made by Rastall and Romanes, no less than six boulders were found bearing a strong resemblance to them. They were collected from the following localities:—

(*a*) Two from fields north of the Madingley Road, 5 miles from Cambridge.

(*b*) Gravel pit, Milton Road.

(*c*) Deep Spring, Biddenham, Bedfordshire.

(*d*) Two found east of the "Golden Lion", Kingston.

Särna is in the Dala district a few miles from Elfdal itself, and about 200 miles north-west of Stockholm. The presence of Dala boulders in England has (according to Milthers) been reported rather indefinitely before.[1]

The important Swedish indicator boulder—the Scanian basalt—has not been definitely found at the pit, but basalts are extremely common, and, owing to the multiplicity of Scottish types and the similarity of basalts generally, no definite results have been obtained.

Three interesting nordmarkites were collected last year. One on a heavy mineral separation yielded a quantity of copper; the other two were sliced, one having a special peculiarity in that riebeckite is developed instead of arfvedsonite, and the other shows strong affinities to this rock.

Three extremely interesting boulders were collected last year, all probably Scandinavian, but their exact locality is uncertain. The first type has been found twice and is a porphyry with extremely fine felspar phenocrysts up to 10 mm. in length, and showing intact crystal faces; the greyish-white groundmass contains abundant green specks which on microscopic examination proved to be ægirine. The second specimen is a gabbro with some affinity to the essexites; it contains some orthoclase, and the uralitic hornblende is blue in places, showing derivation from a soda-bearing augite. The other rock was collected as a largish boulder, and is a syenite with lepidomelane, and was found, when a slice was examined, to contain barkevikite. Neither this rock or the ægirine-porphyry could be matched in the collection of Scandinavian rock-types at South Kensington Museum.

The complete list of Scandinavian types which have been recognized at the pit may be summarized thus:—

Swedish.—Särna porphyry and related types.

Norway: 1. Rhomb-porphyry.
2. Laurvikite.
3. Christiania soda granite.
4. "Copper-bearing" nordmarkite.
5. Riebeckite-nordmarkite.
6. Nordmarkite showing affinities to No. 5.

Doubtful: Barkevikite-syenite.
Ægirine-porphyry.

[1] *Indicator Boulders* and V. Madsen, *Quart. Journ. Geol. Soc.*, vol. xlix, 1893, p. 114.

It is of interest to note that a boulder collected some time ago at Whitby by Dr. Rastall bears a marked resemblance to the Bredvad (Dala) porphyry, described by Milthers.

Turning now to the Scottish types many interesting specimens have been collected.

Firstly, we have the quartz-porphyry from Buchan Ness. This rock has fine phenocrysts of orthoclase, and plentiful quartz grains embedded in a dark, fine-textured groundmass. It is recorded by Rastall and Romanes as being found at Barrington, an exposure now unfortunately largely overgrown. The Barrington specimen was identified as the Buchan Ness rock by Dr. Bonney and Dr. R. Campbell. This year three specimens have been recorded from the Travellers' Rest Pit, but I am not aware of any having been found here previously. Two of the specimens were moderately large and in good preservation.

The next rock of interest is a beautiful alkali-granite with fine crystals of pink felspar and occasional patches of dark ferro-magnesian mineral. I submitted this specimen to Dr. Bonney, who remarked on its strong affinities to both the Ross of Mull and Peterhead granites, the resemblance to the latter being more pronounced; the possibility of its being a specimen of the former being out of the question, and the finding of the Buchan Ness rock just referred to, seem to indicate its being of Peterhead origin. One specimen only has been recorded.

The finding of the Buchan Ness and Peterhead rocks here gives excellent proof of the presence of North Aberdeenshire erratics in the Cambridge drift, and touching on the interesting question as to how they reached this district, new facts have lately come to light. On the map on p. 49 of Mr. W. B. Wright's *Quaternary Ice Age*, the ice flow on the North Aberdeenshire coast is shown as roughly northerly. From this the inference might be that these types were transported indirectly, had it not been for a recent important discovery. In the report of a recent meeting of the Edinburgh Geological Society [1] there is an account by Dr. Bremner of the finding of a boulder of rhomb-porphyry at the Bay of Nigg, just south of the town of Aberdeen, and about 30 miles south of Buchan Ness. This discovery is of the utmost importance, showing as it does that the Scandinavian ice *did* reach the *mainland* of Scotland, and would therefore be sufficiently strong to deflect the easterly flows of the Highland ice in this district, in part at any rate, in a southerly direction, and thus probably accounted for the transport of the Buchan Ness and Peterhead rocks to Cambridgeshire.

The quartz-porphyry recorded from so many localities, not, however, including the Travellers' Rest, by Rastall and Romanes, and referred to by them as porphyry "*x*", has now been identified as being a Scottish type, where it is of fairly wide distribution, being

[1] Geol. Mag., vol. lvii, 1920, p. 522.

a dyke rock of Old Red Sandstone age. It has lately been collected several times at the Travellers' Rest Pit, and can be easily recognized by the weathering out of the quartz grains on the "boulder surface" as black specks.

Cheviot rocks are common and call for no further notice, except that many types are found, including andesites, porphyrites, and porphyries.

Several boulders have been collected of the Old Red Sandstone, which must be erratics from either the outcrop at the Border or from that north of the Firth of Forth.

One of the basalts collected at the pit was sliced, and both the boulder and the slice were submitted to Mr. E. B. Bailey, of the Geological Survey of Scotland. He stated that this specimen was a basalt of the Dalmeny type, approaching in its richness in augite phenocrysts and poorness in felspar in the groundmass to the Hillhouse type, and would be matched exactly under par. *b*, p. 106, *E. Lothian Memoir* (1910).

With regard to the presence of Lake District rocks in this district, more and more evidence is being collected in favour. At the time of publication of Rastall and Romanes' paper the finds were as follows:—

Muscovite granite porphyry } Kingston Lodge.
Andesite }
Andesite with old label: "Drift, Cambridge".
Andesite with old label: "Observatory, Cambridge".

All these andesites are remarkably similar to the andesites of the Borrowdale series. They are well-preserved, compact, dark-green rocks, in which are embedded small laths of felspar. Since then two more specimens have been collected, one in 1909, after the publication of the paper by Rastall and Romanes, at the Milton Road Pit, and one last year at the Travellers' Rest. Thus five similar specimens have been found, all bearing very strong resemblance to the Borrowdale lavas.

The muscovite granite porphyry confirms the other specimens, as it is identical with the Dufton Pike rock.

The cumulative evidence of these types really forces one to the conclusion that Lake District rocks have been transported to the Cambridge area.

With regard to class 4, the north-eastern and eastern English rocks, the following have been found:—

Millstone Grit.
Coal-measure sandstone.
Carboniferous limestone.
Jurassic "oyster bed".
Several other sandstones (common).
Porospheræ.
? Red Chalk.

The latter calls for special caution owing to its great similarity to the Silurian *Orthoceras* Limestone from South Sweden. Unless a specimen contains a fossil it is impossible to state definitely which rock it is.

Noticeable under this heading is the Palæolithic implement found by Professor Marr, which is made from a silicified oolite which Dr. Rastall has identified as being of Yorkshire origin. The rocks from unknown localities are as follows:—

(*a*) *Metamorphic*:

1. Garnet-mica-schist.
2. Hornblende-schist, with quartz veins.
3. Green mica-schist, turning brown in places.
4. Micaceous schistose conglomerate (quartz pebbles).
5. Gneissose granites (comparatively common).
6. Foliated granite with porphyritic microcline.
7. Very much altered gabbro.
8. Gneissose muscovite-biotite-granite.
9. Many quartzites of varying composition.

(*b*) *Igneous*.

1. Muscovite-granite-porphyry.
2. Microgranites, chiefly pink.
3. Many granulites.
4. Many granites.
5. Pegmatite.
6. Markfieldite.
7. Dolerites (common).
8. Felsite.
9. Basalts (common).
10. Three types of rhyolites.

The last is an important point, owing to their practically negligible development in the east of Scotland.

(*c*) *Sedimentary*:

1. Carboniferous chert.
2. Arkose (Sparagmite).

In conclusion I should like to express my gratitude to Dr. Bonney and Dr. Rastall for their great kindness in identifying many of the specimens.

Preliminary Note on the Rocks of Darfur.

By Captain Hubert Lynes, C.B., C.M.G., R.N., and W. Campbell Smith, M.A., F.G.S.

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In the course of a journey from El Obeid to Jebel Marra, in Darfur, Captain Hubert Lynes collected a number of the rocks from the volcano of Dereiba and from various other points on the route, shown in the map (Fig. 1). The rocks of this area have not been described hitherto. The following notes give a brief description of the nature of the country, with petrological details of the rocks collected.

Darfur is a vast plain, clad with bush and scrub, about one-fifth as large as the combined area of the British Isles, with a mean altitude of some 2,300 feet above sea-level. The highest part of this plain lies in the centre of the Province, whence it slopes very gradually downwards in all directions, except, perhaps, to the north. The surface is undulating with huge mile-long sweeps of almost imperceptible gradient, broken only in a few places by shorter and steeper undulations, which form low rolling hills.

The only important structural features which rise from the plain of Darfur are the mountains of Jebel Marra, including the extinct volcano of Dereiba, some high ground observed by Tilho round Mount Durbulla, in approximately lat. 14° N., long. 23¼° E., and numerous groups of lower hills, mainly in the northern part of the Province, rising on the average to about 1,500 feet above the plain. Of the last the most isolated and singular group is that of Jebel Meidob, some 130 miles N.E. of El Fasher, which is reported to contain a crater and a salt-lake.

Between the eastern borders of Darfur and the White Nile stretches the Province of Kordofan, also in the main a vast bush and scrub-clad plain partly studded with denuded hills and kopjes, which to the south merge into the mountainous country of the Nuba Mountain Province. Some of the rocks of this area have already been described by Linck.[1] Before starting on his main expedition, Captain Lynes went south to Dilling, following a route some 12 miles to the west of the El Obeid–Kadero route taken by Linck. The first rocks noticed by Lynes on the El-Obeid–Dilling route were at Khor el Haggis. The specimen collected here (48)[2] is a typical *troctolite*, consisting of equigranular (2 mm. grain) olivine and basic labradorite, near Ab_{37} An_{63}. The felspar is quite fresh, and is traversed by radial cracks emanating from the olivine, which is partly serpentinized, though less so than in the *troctolite* of Coverack Cove (Cornwall).

[1] G. Linck, "Beiträge zur Geologie und Petrographie von Kordofan": *Neues Jahrbuch für Min.*, etc., B.B. xvii, 1903, pp. 391–463.

[2] The numbers in brackets are the serial numbers of the specimens as recorded in the rock-registers of the Department of Minerals, British Museum (Natural History).

The figure of the latter rock in Harker's *Petrology for Students*, 1919 (fig. 24, p. 80) affords a good representation of the Khor el Haggis rock.

The granite of Dilling has been described by Linck.[1] Specimens (45) collected by Lynes show the proportion of potash-felspar (microcline and microperthite) to oligoclase to be 2 : 1. Linck describes numerous dark inclusions in the granite of Kadero, to the east, and they are evidently abundant in the granite of Dilling too. Those collected (46) are fine-grained (0·08 mm.), equigranular aggregates of biotite and felspar (? orthoclase), quartz, and ilmenite (or magnetite), with abundant round grains of sphene, and fine needles of apatite crowding the felspar hosts. These inclusions carry some large crystals of plagioclase full of inclusions. The plagioclase is albite-oligoclase. One crystal showed a more acid centre, with inclusions of blebby quartz.

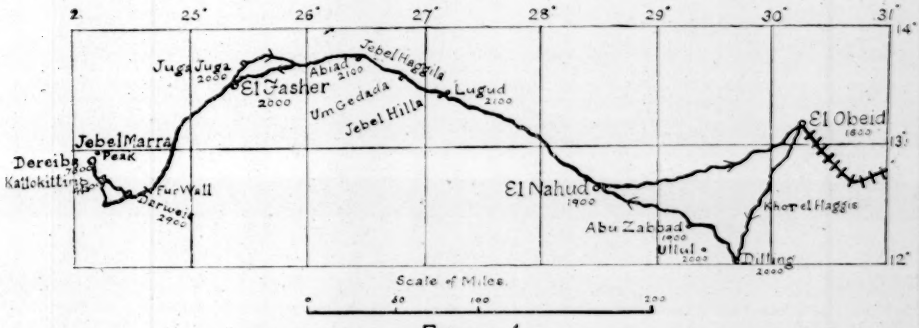

Figure 1.

Fragments of very weathered granite (44) found on a hill near Ullul seem the most westerly representative of the Nuba Mount granites, but at 30 feet, in a well-boring at Abu Zabbad, occurs a pure white pegmatite or *graphic granite* (43). It consists of orthoclase, albite-oligoclase, and quartz, the two last often graphically intergrown, in plates of about 1 cm. in average diameter, with occasional plates of biotite altering to chlorite. Zircon was the only accessory mineral observed.

On the direct route from El Obeid to El Fasher the ground is at first covered with the hard red sand, like that which is so widespread in Kordofan. To the south the Nuba Mountains are seen in the distance, but near the route a very occasional little kopje or rocky outcrop is all that is seen to break the level plain.

At Jebel Waled, 6 miles east of Nahud, sedimentary rocks appear. They are similar to those forming the Lugud Hills, which are described below. A well-boring at Nahud is in pale yellow friable sandstone, containing pebbles of chalcedony (40).

[1] Loc. cit., p. 407.

Soon after leaving Nahud tracks of blown sand are encountered. The hitherto imperceptible undulations contract, and trekking in the soft sand, with its frequent ups and downs, becomes tedious. The screen of bush on both sides of the track deprives the traveller of any view of the country to right or left, except on rare occasions, and then, when these glimpses of the distance are obtained, it is only on the horizon that any features stand out above the prairie-like landscape.

On crossing the frontier into Darfur, the same character is maintained, but with ever-increasing sand, until Jebel Hilla and the Lugud Hills appear, a welcome sight to the traveller, not only by reason of their fantastic forms and unusual colouring, but also as marking the beginning of the "game" country. These hills form a low range flanking the track on the north from Lugud to Abiad. Seen from the south they present a continuous series of flat-topped hills carved by denudation into a variety of shapes, fantastic pillars and "cathedral" masses rising from or flanking the table-tops in endless profusion, and rendered the more remarkable by their many colours, garish yellows, reds, pinks, and purples predominating among light greys and darkest browns. They are formed of sandstones and clays, apparently unfossiliferous, and, as far as can be judged from photographs, everywhere horizontal.

It is not practicable to publish here any of the photographs of these hills, but there is a striking similarity between the type of scenery north of Lugud and that portrayed in Col. Tilho's photographs of the peaks of Dourdouro in Erdi, 300 miles to the north-west, to which the reader is referred.[1] So striking is this similarity that one is tempted to hazard the suggestion that the sedimentary series of Erdi has its south-easterly prolongation in these hills between Abiad and Lugud, with an outlier or further extension to the east at Jebel Waled, near Nahud.

Specimens of these rocks from Jebel Haggila, between Abiad and Um Gedada, are yellow friable sandstone with a little muscovite, pale purple fine-grained sandstone, with occasional pebbles of white quartz, and quartz-conglomerates with hard black limonitic cement (32). At Lugud there are similar sandstones, pink and red, with thin bands rich in hematite (33). In addition there occur some fine decimillimetre-grained clayey sandstones, or sandy clays (33c), rather powdery to the touch, pale cream to palest violet in colour, with irregular streaks of pale lavender tint, which are more sandy and coarser in grain than the lighter coloured portions. On a low 50 ft. kopje, Jebel Hilla, 5 miles south of Lugud, these clayey sandstones occur near the top, and are here associated with pink, white, and pale-buff quartzites (35), very compact and fine-grained. The lower part of the hill consists of dark red friable false-bedded sandstone. These pale violet clayey sandstones seem to be an easily

[1] Jean Tilho, *Geogr. Journ.*, vol. lvi, 1920, p. 93.

recognizable lithological type, and it is their presence at Jebel Waled, where they are being quarried for building purposes, that makes it possible to trace there an extension to the east of this series of sediments.

West of Abiad, the "cathedral peak" country is succeeded by 30 or 40 miles of "goz" country, rolling sandy hills among stretches of level plain, in which the sands are sometimes pebbly and hard and clad more with scrub and grass than with bush.

Crossing the sandy "goz" belt, the track enters a new type of rocky hill country within 30 or 40 miles of El Fasher. The view looking south-west and north-west from a kopje 3 miles north of Juga-Juga shows a few low conical hills projecting here and there from a vast sandy plain, with hill-ranges in the far distance. Here the country seems to be formed of *metamorphic rocks*. Fragments of pink and green *epidotized aplite* (28) were noticed in the "khors" round Juga-Juga. Specimens from one of the low conical hills, "boulder kopjes," are of *biotite-gneiss* (30) and *biotite-amphibolite* (29). The latter is a fine-grained, equigranular, dark-green rock, and consists of brown biotite and green hornblende, with acid oligoclase, some orthoclase, and quartz. The accessory minerals are magnetite (or ilmenite) and apatite in small crystals. Nine miles south of El Fasher a vein of compact white quartz (27) forms the top of a small "kopje", 120 feet above the level of the plain.

Jebel Marra lies some 70 miles W.S.W. of El Fasher. It is a large mountain mass, extending perhaps 50 miles north and south and 20 east and west, with much of its area at a mean elevation of 8,000 feet above sea-level. It forms the dominant mountain-group between the Abyssinian Plateau and the mountains of Nigeria and the Cameroons, while in a north and south direction the nearest high features are the great Equatorial mountains on the one hand, and on the other the Tibesti Range, with the high ground round Mount Durbulla as a sort of connecting-link. The part of these mountains visited was the extreme southern end of the upper zone, where is an extinct volcano with a soda-lake, Lake Dereiba, on the crater-floor at 7,500 feet, and with peaks on the crater-wall rising to 10,000 feet above sea-level.

The route taken from El Fasher to Jebel Marra skirted the mountain system, passing up a more or less gradual ascent, through a heavy sandy belt, to a rocky country and the outlying hills of the Jebel Marra system itself. Here foothills of fantastic shapes fringe all the eastern base of the massif. The vegetation grows more succulent as one gets south, until at Kallokitting, 4,000 feet, at the beginning of the main ascent, there is perennial water in the Wadi Ghindi and quite rich vegetation wherever the water or moisture rises to the surface.

An outlying foothill between Darweis and Kallokitting consists of *biotite-granite rich in oligoclase*, of which two specimens were collected (25). A large slab of the same kind of granite was seen at

Kallokitting, 12 miles to the north (24). The only other specimen obtained from this area is a fragment of a quartz-vein with patches of muscovite, taken from the " fur wall " near Darweis, and believed to occur in situ in the vicinity (26).

One specimen of the granite contains a few flesh-coloured phenocrysts of microperthite, 1–2 cm. in length, and set in an equigranular, millimetre-grained, dark groundmass of oligoclase, quartz, and biotite, with interstitial microcline. Magnetite, apatite, and orthite are accessories. The oligoclase is subhedral, and has strong zonary bands of inclusions. The microperthite phenocrysts enclose oligoclase and numerous rounded patches of quartz. The proportion of potash-felspar (microperthite) to oligoclase is about 6 : 5, as determined by the Rosival method. The other specimen is non-porphyritic, orthoclase not exceeding 0·6 mm. in diameter. It contains the same minerals as the porphyritic type present in similar proportions. But for the absence of sphene, the subhedral development of the oligoclase, and the somewhat greater abundance of biotite, this granite compares well with the Shap granite. It would be classed by Hatch with the " adamellites ", and by Iddings with the " quartz-monzonites ".

From Kallokitting begins the ascent to the crater of Dereiba. This extinct volcano was visited by Mr. J. A. Gillan and Captain H. F. C. Hobbs when on patrol duties in 1918, and the latter published an excellent general description of the crater and of the ascent to it, together with a rough map of the crater itself.[1]

The crater is from 3 to 4 miles in diameter, surrounded by walls 2,000 feet above its floor, and contains two lakes. One, deep and not over-saturated with salt, occupies a subsidiary crater within the main one. The other is shallow and is surrounded by a rim of salt, consisting of carbonate and chloride of sodium (25*a*). Captain Lynes collected samples of water of both lakes, and analyses of these were made by the Wellcome Research Laboratories in Khartoum. The results of the analyses are given in the appendix.

The first exposures of volcanic material were met in the ravines in the foothills above Kallokitting at about 4,000 feet. The sides of the ravines are formed of loose volcanic tuffs (23), some red, others grey or pale brown. The pale-coloured tuff contains much felspar and brown glass. In the crater floor itself white pumice seems to be abundant, and the walls in places consist of light yellow tuff with small lapilli (20), and sometimes of a very fine-grained (0·04 mm.) ash or tuff (21), which readily falls to powder. The latter consists mainly of orthoclase or anorthoclase, with some glassy material and minute needles of pyroxene. A cream-coloured trachyte with

[1] H. F. C. Hobbs, " Notes on Jebel Marra, Darfur " : *Geogr. Journ.*, vol. lii, 1918, pp. 357–63.

Capt. Hobbs' altitudes, for reasons which he himself explains, are inaccurate. Capt. Lynes, who considers his observations correct to within 200 feet, climbed a 9,500 ft. peak (6,000 feet in Hobbs' map, loc. cit., p. 362), and judged several peaks viewed thence to be up to 10,000 feet or over.

porphyritic orthoclase (up to 6 mm. in length) seems abundant at about 8,000 feet; the specimen of this rock (17) is too much weathered to be examined in thin section. A dark bottle-green obsidian (19) was found as rounded masses probably embedded in tuff. It contains a few phenocrysts of felspar with the optical properties of a soda-bearing orthoclase. The obsidian shows perlitic structure strongly developed and on a very fine scale, the glass splintering very readily into minute fragments.

The remaining specimens from Dereiba were, with three exceptions, collected from the top of a peak on the crater-wall (the 6,000 feet peak of Hobbs' map), the height of which Captain Lynes determined as 9,500 feet. Before proceeding to the description of the volcanic rocks reference must be made to the occurrence on the top of this peak of large blocks of rocks which present the characters of metamorphosed, foliated, igneous rocks. The specimens collected include a *biotite-bearing hornblende-gneiss* (7), a fine-grained white *gneiss poor in biotite* (11), and a *hornblende-schist* (9) with labradorite as the predominant felspar, and rich in ilmenite and sphene. There is no evidence at present of the exact mode of occurrence of these foliated rocks.

The volcanic rocks are represented by nine specimens, which are classified as follows:—

Quartz-bearing Soda-trachyte.

These (1 and 3) correspond very closely to the "phonolitic quartz-trachyte" described by Prior from the Great Rift Valley.[1] They are pale grey, often stained brown, with phenocrysts of anorthoclase, 1–2 mm. in length, in a fine-grained groundmass of lath-shaped orthoclase or anorthoclase, with interstitial micro-pœcilitic quartz and micro-ophitic patches of ægirite, cossyrite, catophorite, and, more rarely, arfvedsonite. There are a few micro-phenocrysts of ægirite-augite, and rounded crystals of olivine with dark resorption borders are nearly always present.

The pleochroism shown by the *catophorite* in these rocks is X = pale yellow; Y = smoky brown with rose-red tinge to dark brown, almost opaque; Z = smoky brown with green tinge to olive-green

Two specimens (15) of a similar rock were collected from the entrance to the main crater at 8,000 feet. In these the felspar-laths are shorter, the quartz is not micro-pœcilitic, and the soda-amphiboles are mainly represented by cossyrite. Grey-green augite occurs as micro-phenocrysts in addition to ægirite-augite.

Soda-trachyte.

One specimen (2), with phenocrysts of anorthoclase and rather darker in colour than the above, resembles closely the second type (No. 357 from Kamasia) of Prior's "phonolitic trachytes",[2] but

[1] G. T. Prior, *Min. Mag.*, vol. xiii, 1903, p. 342.
[2] Loc. cit., p. 241.

differs in containing rounded crystals of olivine and a few crystals of labradorite and pale-yellowish augite, which seem quite foreign to a rock of this nature. The labradorite is in one case enclosed in a crystal of anorthoclase; in another case the plagioclase is surrounded by a granular zone of untwinned felspar, augite, and magnetite. The phenocrysts of augite, wherever seen, are surrounded by a zone of small granular augites. Both the augite and the labradorite have the appearance of xenocrysts. This rock also contains numerous patches, 0·2 mm. in breadth, with rectilinear boundaries and made up of blebs of an opaque mineral doubtfully referred to cossyrite; these are probably pseudomorphs, but there is no evidence in the rock as to their origin.

Quartz-bearing Riebeckite-trachyte.

Two specimens (4 and 5) present a striking resemblance to the sölvsbergites (Abuna Alif type) described by Prior[1] from the neighbourhood of Adowa and Axum, in Abyssinia, and which he compared to Brögger's sölvsbergites from the Christiania district. The fresher specimen is cream-coloured, with minute black specks, giving the rock a blue-grey colour, stained red in patches. It resembles the Abuna Alif rock in texture, and in turbidity of the felspar laths, but differs in the possession of a few small phenocrysts (1·8 mm. × 0·8 mm.) of anothorclase, in the presence of quartz as interstitial patches sometimes 0·1 mm. in diameter, and in the presence of abundant *riebeckite* in place of ægirite.

The mineral here referred to *riebeckite* shows two cleavages intersecting at about 120°, X : c = 5°, and pleochroism:—

X = very deep blue-green.
Y = very dark blue, almost black.
Z = pale yellowish-green to olive-green.

Some sections suggest ægirite, but the green shades for X and Y are always very dark. A very similar rock (5) from the same locality is bright red in colour, which is due to the complete decomposition of the soda-iron-silicate, which may have been either riebeckite or ægirite.

There is no evidence as to whether these rocks occur as dykes or flows. On account of the trachytic texture they are classed for the present as trachytes, but their close similarity to Prior's sölvsbergites from Abyssinia must be borne in mind.

Andesine-bearing Kenyte.

This specimen (6) is not strictly comparable with any of the rocks hither to described from East Africa, but its relation to the kenytes is evidently a close one, and it is still more closely related to those rocks of South Victoria Land which Prior has referred to as inter-

[1] G. T. Prior, *Min. Mag.*, vol. xii, 1900, p. 267.

mediate between olivine-basalts and kenytes,[1] and which Jensen described later as basic kenytes or plagioclase-kenytes.[2]

The hand-specimen shows small phenocrysts of felspar, averaging 0·6 mm. in length, in a dull glassy base. Under the microscope the groundmass is seen to be very dark, almost opaque, with scattered microlites of felspar giving straight extinction, possibly anorthoclase, but too thin to be determined with certainty. The other crystals in the glassy groundmass are olivine or its deep-red alteration product, one or two pale yellow crystals of augite, 1 mm. in diameter, several opaque black lozenge-shaped pseudomorphs possibly after hornblende, a few smaller augites of a pale-green colour, and one or two rounded flakes of dark-brown biotite. The felspar phenocrysts are of two kinds, basic andesine, near $Ab_1\ An_1$, and anorthoclase, the latter being present in slightly smaller amount than the andesine. The anorthoclase forms tabular Carlsbad twins, of which the ends are rounded and the sides are frequently embayed by patches of groundmass. It occasionally encloses olivine or its alteration products. The andesine tends to develop euhedral outlines and contains inclusions of groundmass, and in one case small crystals of apatite. In addition to the phenocrysts of felspar the section shows five or six rounded crystals of olivine.

Mugearite.

A specimen chipped from a boulder in the Wadi Ghindi at about 7,500 feet (22) is a fine-grained blue-grey rock with trachytic texture mainly composed of lath-shaped crystals (0·2 mm. × 0·02 mm.) of oligoclase, associated with orthoclase, granular augite, and magnetite, with a few small phenocrysts (< 0·4 mm. diameter) of olivine and magnetite and occasional brown crystals of apatite. This compares so closely with the *mugearites*, described first by Harker[3] and later by others, that one has no hesitation in assigning it to this species.

By the courtesy of Dr. H. H. Thomas I have been able to examine Dr. Harker's type rock from Druim na Criche, near Portree, Skye, and the other mugearites described from time to time by members of H.M. Geol. Survey.

Compared with Harker's type, the Wadi Ghindi rock is much poorer in olivine. Another point of difference is the presence of small phenocrysts of felspar, giving symmetrical extinctions of up to 11°, and consisting of oligoclase slightly more basic than that of the small laths, and sometimes showing a slightly more acid outer zone. The groundmass contains more augite and less magnetite than the type rock, and the augite is granular and not ophitic. The

[1] G. T. Prior, "National Antarctic Expedition, 1901–4": *Nat. Hist.*, vol. i, 1907, p. 106.

[2] H. I. Jensen, "British Antarctic Expedition, 1907–9": *Geology*, vol. ii, 1916, pp. 107–9.

[3] A. Harker, "The Tertiary Igneous Rocks of Skye": *Mem. Geol. Surv. U.K.*, 1904, p. 264.

felspar laths are slightly larger. They give straight extinction and are oligoclase; orthoclase is present, but is less conspicuous than in the type. Apatite does not occur as abundant small crystals, but is represented by a few small prisms, coloured brown by lines of small inclusions and showing pleochroism: X = dark smoky brown, Z = yellowish-brown. Precisely similar apatites are found in mugearites from East Lothian and from Pembrokeshire.[1] The brown hornblende and biotite present in the mugearite of Skye and of other localities is absent. The Wadi Ghindi rock has a density of about 2·6, and is probably more acid than Harker's type.

With the exception of the mugearite and the andesine-bearing kenyte, the above rocks compare very closely with types described from the East African volcanoes. It is interesting to note the occurrence of rocks with similar affinities among those found by Lieut.-Col. Tilho at the volcano of Emi Koussi, in Tibesti, 600 miles north-west of Jebel Marra.[2] Professor Lacroix has not given detailed descriptions or figures of these rocks, but the catophorite-bearing trachyte mentioned[3] will doubtless be found to compare closely with the soda-trachytes or quartz-bearing soda-trachytes above described. The descriptions of the crater of Emi Koussi show that in form it closely resembles the crater of Dereiba.[4]

[Captain Lynes has now returned to Darfur, and intends making a long stay in Jebel Marra to study its natural history. It is hoped that after his return it will be possible to furnish further details of the geology and petrology of the district. In the meantime these preliminary notes may serve to indicate the nature of the rocks which occur in this part of Africa, and to show what interest may be attached to collections from remote parts of the world of fresh rocks taken in situ, carefully located and carefully labelled.—W. C. S.]

Appendix.

Report of the examination of a sample of water sent by Capt. Hubert Lynes, R.N., and received on June 7, 1920.

Sample No. 5728, labelled: "Water and a little green scum from 'Salt Lake', Jebel Marra Crater; altitude 5,700 feet."

The green scum referred to had disappeared, but there was a small amount of dark green sediment, showing organic structure, at the bottom of the bottle.

Sample No. 5729, labelled: "Water from 'Fresh Lake', Jebel Marra Crater; altitude 7,500 feet."

Analysis gave the following results, which are expressed as parts per 100,000 parts of water:—

[1] H. H. Thomas, "The Skomer Volcanic Series": *Quart. Journ. Geol. Soc.*, vol. lxvii, 1911, p. 197, fig. 9*b*.

[2] A. Lacroix, *C.R. Acad. Sci. Paris*, vol. clxix, 1919, pp. 401–7.

[3] Ibid., p. 404.

[4] A. Lacroix, *C.R. Acad. Sci. Paris*, vol. clxviii, 1919, pp. 1237–40, and vol. clxix, p. 403.

	Sample No. 5728	*Sample No. 5729*
Total solids	5,187	552
Containing :—		
Chlorides (as Sodium Chloride)	1,587	174
Alkalinity (as Sodium Carbonate)	3,364	304
Nitrates	trace	trace
Nitrites	absent	absent
Calcium	4	3
Magnesium	0·2	0·2
Suspended matter	small amount	nil

A very small quantity of sulphates was present in both samples. No examination was made for ammonia.

(Signed) H. MARTIN,
Acting Government Chemist.

WELLCOME RESEARCH LABORATORIES,
GORDON MEMORIAL COLLEGE,
KHARTOUM.
July 11, 1920.

Tertiary Gravels of the Buchan District of Aberdeenshire.

By J. S. FLETT, F.R.S., and H. H. READ, F.G.S.

CAPPING many of the hill-tops of the Buchan district of Aberdeenshire there are extensive spreads of gravel containing pebbles of white quartzite and of flint. Their north-western limit is on the Delgaty estate, near Turriff, where, at an elevation of 350–400 feet, there is a small patch of quartzite gravel a mile and a half to the north-east of the town. Nearly eight miles to the south, on Windyhills, two miles north-east of Fyvie, a more extensive outlier occurs. These two patches are shown in Fig. 1. The Windyhills spread is nearly a square mile in area, and it occupies the summit of a low flat-topped ridge at an elevation of 370–400 feet. Like the Delgaty gravels, it is evidently the remains of a deposit formerly much more extensive and reduced greatly in area by denudation. It consists mainly of white quartzite pebbles, flint pebbles, and white clayey sand, and its resemblance to the Delgaty gravels is so close that no doubt has been entertained that they belong to the same period and formation.

In Central Buchan, along the top of a low, flat-backed ridge, which may be called the Buchan Ridge, extending from a little north of Ellon to Buchan Ness, south of Peterhead (see Fig. 2), there are great stretches of gravel, consisting mainly of water-worn flints, with a smaller proportion of white quartzite and other pebbles. As a rule these pebble beds are confined to the hill-tops at elevations of 350 feet and over, though numerous scattered flints are found at lower levels. These gravels of the Buchan Ridge differ in several respects from the Delgaty and Windyhills gravels, but their similarity in essentials is so close that none of the previous observers has doubted that they belong to the same series of deposits.

Much attention has been given to the Buchan gravels by Aberdeenshire geologists. Christie [1] of Banff, was perhaps the first to give an account of the occurrence of chalk flints at Delgaty. In 1857 J. W. Salter [2] described the fossils from the chalk flints of the Buchan Ridge; to this description Ferguson of Kinmundy

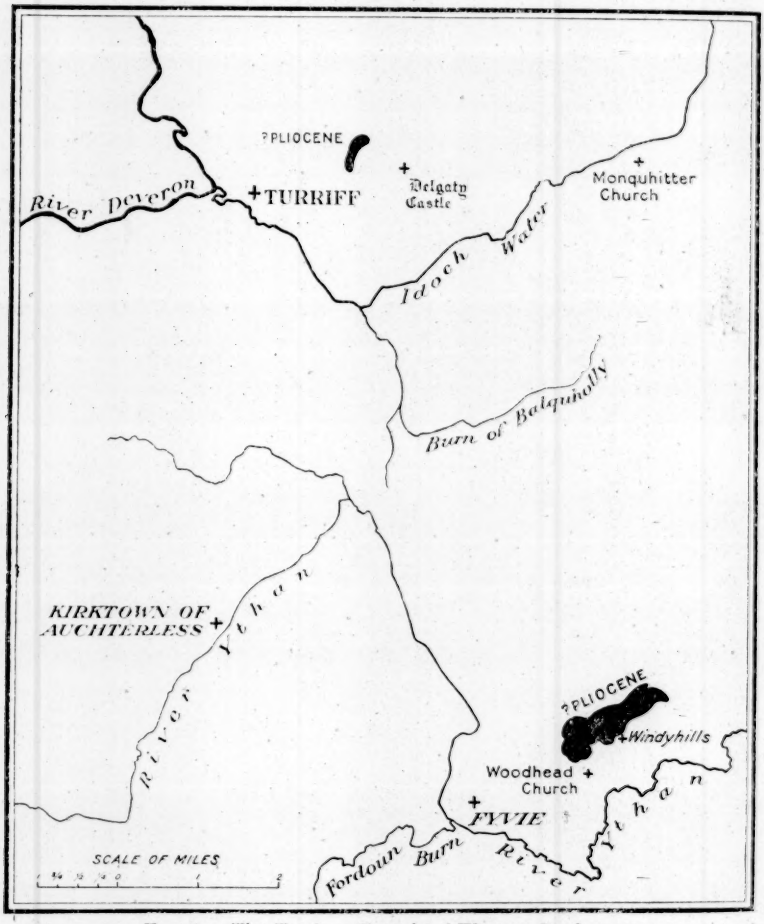

FIG. 1.—The Tertiary Gravels of Western Buchan.

appended a brief account of the distribution of the gravels. These deposits were studied especially by T. F. Jamieson of Ellon, who was intimately familiar with them throughout the area. In his first paper Jamieson described the gravels of the Buchan Ridge

[1] *Edinburgh New Philos. Journ.*, vol. x, 1831, p. 163.

[2] "On the Cretaceous Fossils of Aberdeenshire": *Quart. Journ. Geol. Soc.*, vol. xiii, 1857, p. 85.

and of Windyhills.[1] The quartzite material at Windyhills, he held, was derived from the underlying Highland Schists, and thus the gravels were local. He gave an outline of the Buchan Ridge along its length. Two years later he gave a sketch-map showing the distribution of the gravels in Buchan.[2] In 1865 he described the Delgaty deposits in some detail; he showed that the gravels were there covered by boulder-clay, and he grouped these gravels with those of Windyhills and the Buchan Ridge as *Preglacial Traces*.[3] In his last paper,[4] which may be considered to express his final conclusions, Jamieson says:—

> No remnant of pre-Glacial Tertiary deposits has hitherto been found in any part of the area (loc. cit., p. 13).

He now admitted that the material of the gravels is not of local origin, but rolled and long travelled. Most important is, however, his withdrawal from his position that these gravels were pre-glacial. He says:—

> The Chalk flints . . . have . . . I suspect, been brought from the Moray Firth by . . . glacial agency. These Flints . . . may have been shed off along the southern border of one of the streams of ice which brought so great a quantity of other debris from the Moray Basin (loc. cit., p. 29).

With regard to the Delgaty section, Jamieson considered the boulder-clay which there covers the gravels to be due to "a recurrence of glaciation after the flints were laid down". Dr. Bremner[5] has assembled the theories on the origin of these deposits, and has pointed out that a study of the quartzites would be most likely to lead to some definite result.

The Delgaty Outlier.

At Delgaty the quartzite gravel covers a small area, only a quarter of a square mile, on the summit of a hill whose highest point is 399 feet. The base of the deposit may go down to near the 350 feet line. This hill is by no means the highest in the district, as there are others within a few miles of it rising to five or six hundred feet, but these hills have rock at their summits or are covered only by a thin skin of boulder-clay. The country rock is Macduff Slate of the Highland Schists, and red sandstones of the Middle or Orcadian Old Red, and the Delgaty gravel seems to rest on both of them in different parts of its area. Most of the outlier is covered by heath and wood, and there is no cultivation; the exposures in ditches and small overgrown pits are few and unsatisfactory. Fortunately, however, there is a gravel-pit which is being actively worked for

[1] "On the Pleistocene Deposits of Aberdeenshire": *Quart. Journ. Geol. Soc.*, vol. xiv, 1858, p. 528.

[2] *Quart. Journ. Geol. Soc.*, vol. xvi, 1860, p. 348.

[3] "On the History of the Last Geological Changes in Scotland": *Quart. Journ. Geol. Soc.*, vol. xxi, 1865, p. 164.

[4] "The Glacial Period in Aberdeenshire and the Southern Border of the Moray Firth": *Quart. Journ. Geol. Soc.*, vol. lxii, 1906, p. 13.

[5] "Problems in the Glacial Geology of North-East Scotland": *Trans. Edin. Geol. Soc.*, vol. x, 1916, p. 344.

pebbles and clay and affords excellent sections, which give a very satisfactory idea of the composition and structure of the deposit. The working face of this pit is at present 8 feet high, and a small excavation in the floor of the pit reveals another foot or two of greyish-white sandy clay with pebbles. The base of the deposit is not anywhere exposed, and the thickness is consequently not known, but is presumably not less than 8 or 10 feet at this place.

The largest pebbles are about a foot in diameter, but the majority are from 2 to 5 inches. Most of them are very well rounded, and the whole deposit gives the impression that the pebbles have suffered much attrition and resemble those found on a sea-beach where wave action has been long continued. Quite nine-tenths of the pebbles are quartzite, of a very fine and pure variety, and all these are perfectly waterworn and rounded. The quartzites are by no means uniform in character. Most are fine-grained, granular or granulitic when examined with the lens, and contain very little felspar or mica. Others, however, have white mica flakes in thin shimmering films, and might be described as very fine-grained white quartz-schists. Still others have a more crystalline appearance, with large areas of clear glassy transparent quartz; no other minerals can be seen in the hand specimen.

Taking the quartzites as a whole, we may say that they have well-defined characters, which are: (*a*) their white colour; (*b*) their great purity; (*c*) their highly metamorphic and crystalline texture. They are certainly not derived from the local rocks, which, as already said, are Macduff Slates and Old Red Sandstone, and, furthermore, there are no known Aberdeenshire or Banffshire quartzites from which it seems possible they could have been derived. The Durn Hill and Cullen quartzites of Banffshire contain usually biotite and orthoclase, which give them a yellowish or pinkish colour when they are weathered. The quartzite and pebbly grit bands of the Macduff Slates are even more impure. Quartz veins are not common in N.E. Scotland, and most of the Delgaty pebbles are not derived from quartz veins. Altogether their origin is a problem on which little light has been thrown by the investigations of the geologists who have studied the rocks of the Eastern Highlands. Their lithological characters, however, are so well marked that it is seldom difficult to identify one of these pebbles in any of the superficial deposits of the district.

Less than one-tenth of the pebbles are flint, and these have the general character of flint pebbles wherever met with. They range up to 9 inches in diameter, and it is not seldom apparent that they are less perfectly rounded than the quartzites, though many of them are extremely waterworn. The flint is soft and brittle and cracks readily under the hammer; the broken faces have often a dull or waxy lustre; pure black flint is practically never seen, but grey, brown, red, and greenish colours are prevalent. Often the flints have a thick dull rind, which is grey or white, and sometimes

they are completely altered to a white mass resembling chalk in appearance. These changes indicate long continued weathering *in situ*, probably by percolating water.

The matrix of the pebble bed varies somewhat in composition and abundance, but is on the whole remarkably uniform. It may be described as a sandy clay always containing quartz grains, but, when wet, distinctly plastic and tough. There is little evidence of stratification in this pit, though the pebbles are not quite evenly distributed in the different layers; no proper bedding or current bedding can usually be seen, but streaks occur, often several feet in length, in which the sandy, clayey matrix is more than usually abundant. Such bedding as can be detected or suspected is horizontal. In the floor of the pit a small excavation had been made which we were informed was for the purpose of working a clayey stratum; this clay is found especially suitable for patching drains.

The working faces of the Delgaty Pit show very clearly that the pebble bed is covered by boulder-clay. This forms a layer, about 2 feet thick, of tough brownish sandy clay, with pebbles of many local rocks and some far-travelled stones derived from districts to the north-west. In the boulder-clay there are also some pebbles of quartzite from the gravel below, and these increase in numbers in the deeper parts of the boulder-clay. The base of the glacial deposit is fairly well marked by the change of colour. No disturbance of the gravels immediately beneath the boulder-clay is to be seen. In Lower Banffshire and neighbouring parts of Aberdeenshire we have found that the south-easterly drift is the earliest of which traces have been preserved.

In the wood, to the south-west of the gravel-pit, there is an old adit or tunnel in the Delgaty gravel, which had been formerly worked for a fine white, sharp sand, which, we are told, was used for scouring kitchen tables. The roof of this adit is formed by stiff brownish boulder-clay, held together by tree roots.

The real base of the Delgaty deposit is not exposed, and the deposit parts now being worked are quite as free from local rocks as any other part of the pebble bed.

The Windyhills Outlier.

This outlier is situated about 2 miles N.E. of Fyvie Church at the top of a low ridge at an elevation of about 400 feet. Perhaps half of the ridge is slightly over the 400 feet contour; the height of the margin of the deposits is not less than 360–370 feet. The underlying rocks are slate and knotted rocks of the Macduff and Fyvie groups of the N.E. Scottish metamorphic rocks; these contain bands of dark, impure, pebbly grit and quartzites in many places. The area covered by the pebble beds is about a mile and a half long in an E.N.E.–W.S.W. direction, and nearly half a mile in breadth. Heather and wood cover most of the ground, and cultivation stops practically at the margin of the gravels, but a

thin sprinkling of white pebbles in the surrounding fields shows that the deposit had once a more extensive distribution. This also makes it somewhat difficult to lay down a definite margin for the outlier on the map.

Many small pits have been opened in the pebble beds, principally with the object of obtaining road metal. Most of these pits are abandoned and overgrown, but there are three or four, widely scattered, still in use, and these furnish very good sections of the different parts of the mass. The largest pit is on the south side about the middle of the outlier, and this is probably the best exposure at present available for examination.

In this pit the working face is about 12 feet high. No boulder-clay is seen above the gravels. The deposit is in every respect very closely similar to that of Delgaty. The pebbles are perfectly rounded white quartzite and quartz-schist, with a small proportion of rather decomposed flints. Stratification is barely visible, though not completely absent, and there are streaks less rich in pebbles, 12 feet or more in length and somewhat lenticular in outline. The bedding is horizontal and undisturbed. The matrix is white or pale yellow, sometimes very rich in fine scales of white mica, but never so quartzose that when kneaded with the fingers it is not distinctly plastic and coherent. The peculiar characters of the quartzite pebbles of Delgaty which give that deposit such a marked individuality are all seen at Windyhills, and there is no room for doubt that the pebble beds of these two localities, which are 8 miles apart, belong to the same series. Some of the pebbles in the Windyhills pits are composed of black and blue quartz, others are of a decomposed whitish chert.

The other smaller pits at Windyhills exhibit the same features, and do not merit a special description. They are all in pebbly beds and have been dug for pebbles; if there are sandy or clayey facies of the deposit they are not now being worked. An exception occurs, however, in a small pit near the west end of the outlier, on its south side; in this a brown clay was dug, full of slate fragments, and with comparatively few quartzite pebbles. It seems that we have here a part of the floor of slate on which the gravels rest, but the relations were not absolutely clear. A somewhat similar clay is visible in a small pit in the wood near by. Here large angular fragments of the underlying metamorphic rock are abundant in a brown clay. A small excavation with a pick showed that these rock fragments increase in number and size below, and it is probable that the underlying solid rock would be met with in a short distance. This bed, at any rate, contains no other rocks, and the fragments are angular. It does not seem likely to be a boulder-clay, though that possibility was not absolutely excluded.

With this possible exception, the base of the gravel is not visible. On the other hand, there was no good exposure showing overlying boulder-clay. Scattered erratics of local rocks may be found on the

surface of the outlier, and at its edges, especially on the north side, it seems to be overlapped by a thin skin of boulder-clay, but no good section proving this was observed. The evidence led us rather to believe that, like many of the adjacent hill-tops, Windyhills rises through the general spread of drift which mantles all the lower ground; the pre-glacial rocks thereby emerge at the surface.

From a consideration of the evidence detailed above, certain conclusions seem to be reasonably clear.

The Delgaty and Windyhills deposits exhibit peculiarities which demonstrate that they are essentially the same. They are parts of a deposit once probably continuous, the relics of an extensive sheet of gravels, sands, and clays, now almost wholly removed by denudation. It is very significant that they both occur at elevations of 360–400 feet; possibly they rest on an old platform, at any rate, they indicate submergence. It seems impossible to believe that they are stream gravels, as this would involve the former existence of a river system, of which no other traces can now be found. Almost certainly they are marine, and point to a general depression of this part of Scotland amounting to at least 400 feet.

As regards their age, only two points are certain. They are post-Cretaceous because they contain flints with chalk fossils; they are pre-glacial because they are covered by a boulder-clay which is, so far as we know, the earliest glacial deposit of the district. It seems safe, accordingly, to regard them as Tertiary.

All the available evidence points to the conclusion that these gravels are *in situ*, and almost undisturbed. No boulder-clay has been found beneath them, and the field evidence indicates that they rest immediately upon a platform of the older rocks. No veins of boulder-clay can be seen in the pits. We know of many large erratics that have been transported by ice without having their stratification greatly disturbed. But the nature and size of these gravel masses, their composition, the freedom from contortion, veining or intercalations of boulder-clay, and, above all, their remarkably uniform elevation above sea-level, point unmistakably to their interpretation as pre-glacial accumulations. The ice in this part of Aberdeenshire was perhaps comparatively thin and moved slowly. In many places the rotten rock below the boulder-clay shows that locally the ice had little excavating power. Many of the peculiar quartzite pebbles of Windyhills type are found in the glacial deposits, and show that much destruction of these beds took place; what remains is probably only a fragment which has escaped erosion.

Gravels of the Buchan Ridge.

About 15 miles east of Windyhills there is a low flat-backed ridge that runs in an east-north-east direction from Whitestone Hill (530 feet) and Dudwick Hill (572 feet) to Stirling Hill and Buchan Ness (see Fig. 2). The flint gravels of this Buchan Ridge are very

well known, and have been described by Ferguson [1] and Jamieson.[2] The length of this ridge is about 10 miles, and it is not crossed by any important valley. Towards its eastern end the ridge is cut through by a narrow channel at North Aldie, which Dr. Bremner [3] has shown to be a glacial overflow channel. It was not possible for us to make a minute examination of the whole of this ground, but we have visited a number of selected localities for the purposes of comparing these gravel deposits with those of Windyhills and Delgaty.

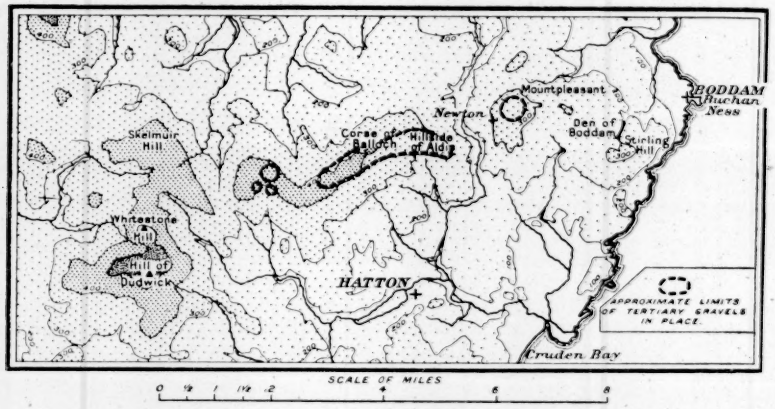

FIG. 2.—The Buchan Ridge. (Contour intervals of 100 feet; height indicated by depth of stippling.)

Towards the west end of the Ridge, about Dudwick Hill, quartz and flint pebbles are numerous in the soil of the fields and on the surface of the moors, but in the numerous shallow pits and drains which we inspected we saw nothing strictly comparable with the Windyhills deposit, and our conclusion was that beneath the soil there was a brownish boulder-clay, in which many flint and quartzite pebbles had been incorporated along with fragments of a large variety of local rocks. Further east, however, at the Corse of Balloch the superficial deposits are of different character. There is a great deal of thick peat in this area which is being extensively dug for fuel; immediately below the peat there are great sheets of gravel, apparently hardly disturbed. By far the greater part of the pebbles are well-rounded flints from 2 to 7 inches in diameter; these form about 80 per cent of the whole accumulation. The remaining pebbles are principally white quartzites, in which all the types characteristic of Windyhills and Delgaty are represented. The matrix is a whitish, or sometimes yellow, sandy clay, varying in

[1] Op. cit., *supra*.
[2] Op. cit., *supra*.
[3] Op. cit., *supra*, p. 339.

character, but often extraordinarily like the clays that accompany the pebbles at Windyhills and Delgaty. On the surface with these pebbles occur fragments of slate, knotted schist, pebbly grit, granite, norite, hornfels, and other rocks of local derivation.

Unfortunately, the few natural exposures are very unsatisfactory and there are no pits at present being worked, as these pebbles are not used for road metal except on the farm roads. Consequently it is very difficult to obtain an exact idea of the composition and structure of the beds and their relations to the glacial and metamorphic rocks.

At the east end of the Corse of Balloch the peat gets thinner and cultivation encroaches on the area of gravel. At Hillside of Aldie traces of many shallow pits are visible. They are now nearly filled up, but we were told that they were sunk in search of a whitish clay which it was thought might be of value. Samples were examined, but it was reported that the material was not of economic value, though when the clay was washed it was possible to make clay pipes from it. Some of these pits are said to have been 10 to 12 feet deep in the gravel without reaching the subjacent rock. The whole surface of the ground is covered with rounded flints and quartzites, while pebbles of metamorphic rocks, deeply weathered, are numerous. We dug for about 3 feet into the gravel, and after a foot or so of peaty soil with iron pan, we reached apparently undisturbed flint gravel embedded in yellow and whitish clayey sand. The pebbles were all very well rounded flint and quartzite; the flint had a thick white weathered crust, and when split open presented a waxy rotten appearance, like the flints at Windyhills.

At North Aldie it was possible to lay down the margin of the outlier with fair definiteness at 300 feet. Below that the pebbles were frequent in the soil, but were obviously transported down the slope. The deposit seemed to rest directly on the granite, which is here the country rock.

On the hill-top a mile or so further east, near Newton and Mountpleasant, the same phenomena are repeated. The lower slopes are granite and red boulder-clay, with mounds of glacial gravel and sand. As the 300-ft. contour is approached pebbles of flint and quartzite become very numerous in the fields, and above that level we pass suddenly on to beds of solid flint gravel capping the hill-tops. The field exposures indicate that this gravel has a nearly horizontal base resting upon a platform of granite, which shows minor irregularities in the form of low granite ridges emerging through the gravels. At least 90 per cent of the pebbles are flints from 2 to 7 inches in diameter, very well rounded, and deeply weathered. Pebbles a foot long are rare. Pure white quartzite pebbles are always present, though only in subordinate amount, and there are also local granite and schist pebbles. No stratification is visible. Large erratics of granite occur scattered over the ground, but we saw no section which established the relations

between the gravels and the boulder-clay. Most of this high ground, in fact, has little boulder-clay upon it, and probably any such deposit was originally thin and irregular in its distribution, and has been largely washed away by rain.

Boddam Den.

Towards the east end of the Buchan Ridge, about a mile and a half south-west of Buchan Ness and a mile north of Longhaven Station, a remarkable dry valley runs northwards across the granite hill. It is about 70 feet deep, and is occupied by only an insignificant streamlet; the floor of the valley is covered with peat, and its northern half is converted into a lake by means of an artificial dam. The course of the channel is at first north-east, then north, and it opens into flat country at each end.

As pointed out by Dr. Bremner,[1] it is undoubtedly a temporary glacial channel, by which melt water from ice sheets has escaped across the ridge. On both sides of the valley the slopes are steep, and on the west side are covered by flint gravel; on the east side also the gravel occurs, but towards the north end of the channel granite crops out on the eastern slope. Many small pits have been opened in the flint gravel, and on the banks of the reservoir the waves have cut good sections 10 feet or less in height. An examination of these shows that the gravel is not washed by stream action. There are no sandy layers, bedding, or current bedding such as are usual in materials deposited by glacial outwash, and it is entirely different in character and composition from the glacial gravels of this district. The surface characters are in some measure affected by rainwash and soil slips from above, but a small pit which we dug for about 2 feet at the north-east end of the dam exposed true flint gravel with yellowish and white fine plastic clayey sand as matrix, exactly similar to the deposits at Hillside of Aldie, Mountpleasant, Delgaty, and Windyhills described above. The pebbles are perhaps 90 per cent of flint; the remainder are the quartzites typical of these deposits. The characters, in fact, are those of undisturbed Tertiary beds.

A careful scrutiny of the exposure at the locality mentioned showed that this gravel is overlain by reddish tough boulder-clay, containing pink felspars and fragments of the Peterhead granite, which is the country rock. The gravel, we hold, is lying in a valley originally cut in the Tertiary platform, filled up by the flint gravel and re-excavated at the close of the glacial period. The coincidence seems remarkable, but it may be suggested that the presence of a gravel-filled hollow would probably determine the situation of the glacial overflow channel by the rapid deepening of any stream-course which happened to coincide with it. This patch of flint gravel apparently marks the eastern end of the Tertiary deposits preserved in this district.

[1] A. Bremner, op. cit., p. 339.

Conclusions.

We have now described the gravels of Buchan, and have given our reasons for regarding them as relics of Tertiary beds of possible Pliocene age. If our contention is correct, the amount of erosion since Pliocene time is seen to be very great.[1]

These Aberdeenshire deposits appear to rest on some kind of platform near the 400 feet contour. This at once recalls the well-known Pliocene platform of Cornwall, described by Clement Reid, Mr. George Barrow, and others. Further, there is a great likeness in position and stratigraphical relations between the Aberdeenshire gravels and those from near Berkhamstead, described by Mr. C. T. Gilbert and Mr. Barrow.[2] It appears likely, then, that in this distant corner of N.E. Scotland there are traces of Tertiary features and deposits similar to those of Cornwall and Hertfordshire.

The contents of the Buchan gravels are dominantly quartzite in the west and flint in the east parts of the outcrops. With regard to the source of the materials, few definite statements can yet be made. The quartzite is certainly not derived from any Aberdeenshire or Banffshire quartzite. The only rock known to us which is at all like it is the Scarabin quartzite in the county of Caithness. The confirmation of this suggestion requires a more detailed petrological and field study than we have yet been able to give.

[1] Cf. George Barrow, *Proc. Geol. Assoc.*, vol. xxx, 1919, p. 36 et seq.
[2] *Quart. Journ. Geol. Soc.*, vol. lxxv, 1919, p. 32.

REVIEWS.

DEVONIAN FLORAS: A STUDY OF THE ORIGIN OF CORMOPHYTA. By E. A. NEWELL ARBER, M.A., Sc.D., with a preface by D. H. Scott, M.A., LL.D., Ph.D., F.R.S. Cambridge, 1921. Price 17*s.* 6*d.* net.

IN forming an estimate of this book it is important to take into account the circumstances in which it was published. Dr. Arber did not live to complete the work; he left it in the state of "a first draft which he was never able to revise". Had he lived to read the later memoirs by Dr. Kidston and Professor Lang on the Rhynie Devonian plants, he would undoubtedly have modified some of his conclusions. Mrs. Arber, who revised the MS., says in a prefatory note: "I do not think that anything in his scientific life gave him a keener intellectual pleasure than the development of the idea—the *Leitmotiv* of the present essay—that the transition from the Algæ to the Vascular Cryptogams no longer remains a matter of pure conjecture, but that, in the fossil plants of the Devonian rocks, we witness, actually occurring beneath our eyes, the passage from the Thallophyta to the Cormophyta." In the preface Dr. Scott writes: "We stand at a new point of departure in our theories of the evolution of the higher plants. Arber was one of the first to realize this, and his memoir represents a bold and vigorous effort to grapple with the problems as they presented themselves to him at the dawn of a new epoch." The publication after Dr. Arber's death of Dr. A. H. Church's already well-known essay on "Thalassiophyta and the Subaerial Transmigration", in which, with considerable ability and force, arguments are adduced in favour of the origin of land plants from complex types of seaweeds, has directed the attention of botanists and geologists to problems of evolution having much in common with those discussed in the *Devonian Floras*. These considerations, whether or not readers agree with the views expressed, furnish arguments in support of the decision to preserve in a permanent form the opinions of one of the most devoted students of palæobotany who ever lived.

The volume is attractively printed and well illustrated, and an admirable portrait of the author is reproduced as a frontispiece by permission of the Editors of the GEOLOGICAL MAGAZINE. During the Devonian there were two distinct terrestrial floras, an earlier *Psilophyton* flora and a later *Archæopteris* flora, differing more widely from one another than the Upper Devonian flora differed from that of the Lower Carboniferous period. A summary is given of the geological age of the several Devonian floras described in a widely scattered literature; the inclusion of all the Old Red Sandstone plants from Caithness in the Upper Devonian flora is surely incorrect. The age assigned to the Caithness beds is not in accordance with the views expressed in the Survey Memoir which Dr. Arber

quotes. Dr. Arber believed that the recently discovered genus *Rhynia*, founded on petrified specimens from Aberdeenshire, is identical with Dawson's *Psilophyton*. It is certain that the two are very closely allied, but their generic identity has hardly been established. It is contended that *Psilophyton* and other Middle and Lower Devonian plants, despite the possession of a well-developed water-conducting strand of xylem, were Thallophyta and anatomically half-way between Thallophyta and Pteridophyta; they are assigned to a new group, the Procormophyta. The much more highly differentiated Upper Devonian plants, grouped under Sphenopsida, Palæophyllades, Pteropsida, and Lycopsida, are believed to represent distinct lines of evolution from Algal ancestors; the development of this view is an important part of Dr. Arber's thesis.

That *Psilophyton* and its associates were in some respects primitive is practically certain, but to regard them rather as Thallophytes than Pteridophytes is in effect to dispense with the recognized distinctions between these two classes. It may be that as we learn more about the oldest terrestrial plants we shall realize the futility of class distinctions based on existing types; class labels are, after all, of secondary importance in comparison with the wider question of the origin of the vascular plants, and it is from this broader standpoint of evolution that we should weigh the arguments presented by Dr. Arber.

A. C. Seward.

Palæogeography and Diastrophism in the Atlantic–Arctic Region during Palæozoic Time. By Olaf Holtedahl. Amer. Journ. Sci., vol. xlix, No. 289. January, 1920.

In studies of palæophysiography the Americans have been recently to the fore, and a summary of their work has appeared in *Outlines of Geological History, with special reference to North America*, by Bailey Willis & Rollin D. Salisbury, published in 1910.

In the present paper Dr. Holtedahl carries this work into the European region which most nearly approaches the American continent, and discusses the distribution of land and sea and the diastrophic changes which have occurred from early Cambrian times to the end of the Carboniferous period. Incidentally he remarks that "it will certainly be hopeless for the advocates of permanency of the oceanic basins to apply the theory to the Norwegian sea".

The construction of palæophysiographical maps is a dangerous thing, and study of these maps often shows the striking dissimilarity of supposed ancient land-masses from any existing land-area. The narrow tract of land represented in this paper as extending from Scotland to Scandinavia in Ordovician times is an example of this. But the author has taken into account the character and distribution of the Palæozoic rocks of the area under consideration in far greater

detail than previous restorers of Palæozoic lands in Northern Europe, and has accordingly made a marked advance in this study. All students of the Palæozoic rocks should read his paper.

J. E. M.

NOTES ON GEOLOGICAL MAP-READING. By A. HARKER. 63 pp. Heffer & Sons. Cambridge. Price 3*s.* 6*d.*

THE very modest title of this book does less than justice to its contents, for in spite of its brevity it manages to cover most of the ground in a thorough way, and is likely to find a wide distribution as a class book. The author begins with a very clear exposition of the meaning of topographical maps, and the way in which they serve as the basis for geological maps, taking the 6 in. Ordnance map as a type. He goes on to consider the simpler forms of geological maps and the various operations required in their interpretation. The argument passes on to unconformable series and then to faults. Folded strata of different degrees of complexity then receive attention, and a systematic method of constructing sections is described. The point is well emphasized that sections are merely illustrations, and cannot take the place of the map itself, and that the student must be able to interpret a map without having to reduce it to sections. Cases of all reasonable complexity are actually illustrated and explained.

One can find nothing but praise for the order of treatment and for the general lucidity of the explanations. The method of using gradients for dip problems instead of vertical angles will be welcomed by teachers, especially those who are accustomed to use graphic constructions dependent on the accuracy of a rough protractor.

On the other hand, the figures call for criticism. From the student's point of view they are far from clear, and one or two are liable to confuse rather than to aid the text, as, for instance, the diagram showing the relations between strike, slope, and outcrop (p. 17). One feels that the book would have been much improved by a few block diagrams in illustration of the maps or of imaginary types of landscape. The maps themselves are models of clearness, but students will find it advisable to colour them before attempting to interpret them.

All geologists will welcome this small book, but will wish that it had been expanded into a manual and were illustrated with more care.

SOUTHERN RHODESIA: THE GEOLOGY OF THE ENTERPRISE MINERAL BELT. (Bull. No. 7.) By H. B. MAUFE. pp. 52 and map. 1920.

THE chief mining camp of the area examined is Arcturus, situated 22 miles due east of Salisbury, and at an elevation of 4,600 feet. Highly folded schistose greenstones and sediments form a complex (the Basement Schists), almost surrounded by granite, of which there

are several phases and dyke-like modifications. An even-grained dolerite, with chilled margins, forms sills, dykes, and stocks among both the schists and the granitic rocks, and is considered to be of the same age as the dolerite of the Karroo Beds, or possibly, as that of the "great dyke" of Waterberg age. Outliers of Kalahari Ironstone (Upper Cretaceous) are mapped on the higher land near the Salisbury Water Works.

The greenstone schists were originally volcanic rocks and range from intermediate to ultra-basic, the commonest being a fine-grained epidiorite derived from dolerite or basalt. The ultra-basic types are now represented by serpentine, and talc- and tremolite-schists. The present structure and mineralogical constitution is due to regional metamorphism accompanied by high temperature without much shear. Evidence of contact alteration by the granite is confined to minor changes quite near the mass. The sediments which are folded in with the greenstones comprise banded ironstone, black phyllite, and limestone. The banded ironstone is a quartzite with layers of varying thickness containing abundant magnetite, originally a ferruginous sandstone. It has been worked for iron-ore by the natives. The phyllite is dark chiastolite slate grading into mica schist. The limestones are coarsely crystalline and contain green amphibole as a metamorphic product.

The granitic rocks show a great variation in form and composition, but they are all of about the same age. They occur as bathyliths, stocks and vein-like intrusions or irregular bodies of aplite and pegmatite, the last being greisenized and stanniferous. Oligoclase is the principal felspar.

A variable series of felsites, quartz-sericite-schists, and ultra-acid intrusives of the same age as, or in part penetrating, the granite, occur as irregular bodies or in dyke-like forms. They possess a dominant cleavage in the direction of flow-structure, due to the orientation of the biotite and sericitic mica.

The Kalahari Ironstone is an æolian deposit, consisting largely of polished quartz-grains, and near the base of amygdules of chalcedony from Karroo basalts. The iron-ore near the base is in the form of sandy nodules surrounded by hard crusts of limonite. It is thought that the iron may have been derived from wind-borne chalybite which has been deposited among the sand and subsequently carried down and deposited as limonite.

The gold reefs are classified as "Schist Reefs" and "Quartz Reefs". The latter are fissure veins, either (*a*) crossing the Basement Schists, as in the case of the Perseverance Reef, or (*b*) roughly parallel with the planes of cleavage. Gold in the quartz veins is seen to occupy rusty cavities formerly containing auriferous pyrites and possibly arsenical pyrites. Below the zone of oxidized ores the gold occurs in auriferous pyrites, and is termed "refractory ore", owing to its not being free milling.

The "Schist Reefs" are more abundant and are replacements or

impregnations along belts of joints in the Basement Schists. The chief introductions are auriferous pyrites, arsenical pyrites, and silica. These may be termed metasomatic deposits, in which the epidiorite is altered to a coarsely crystalline biotite-actinolite schist with auriferous sulphides. The outer sides of this rock merge gradually into the normal epidiorite. In some cases there is a thin quartz vein or succession of quartz lenses along the main joint or fissure, and gold may occur in these as well as in the schists. There appears to be a striking connexion between these veins and the acid and ultra-acid felsites mentioned above.

The author has described the physical features of the district in some detail and with remarkable clearness.

EVERY BOY'S BOOK OF GEOLOGY: AN INTRODUCTORY GUIDE TO THE STUDY OF THE ROCKS, MINERALS, AND FOSSILS OF THE BRITISH ISLES. By ARTHUR E. TRUEMAN and W. PERCIVAL WESTELL. pp. 1–315. R.T.S., n.d. [1920]. Price 6*s*. net.

THE aim of this work is to arouse in young people an interest in the study of geology. The authors have made a judicious selection of the more attractive parts of the subject, and the book is written in plain and simple language, which should make it suitable for juvenile readers. The illustrations are numerous, and although sometimes a little crude, they serve the fundamental purpose of making the text easily intelligible. There is no connected account of stratigraphical geology, but the nature of the geological record is well shown by the chapters on "Coal and Coal Mining" and "The Great Ice Age".

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN. Vol XII, IRON ORES (CONTD.): BEDDED ORES OF THE LIAS, OOLITES, AND LATER FORMATIONS IN ENGLAND. By G. W. LAMPLUGH, F.R.S., C. B. WEDD, B.A., and J. PRINGLE. Mem. Geol. Survey. pp. iv + 240, with 8 plates and 12 figures. 1920. Price 12*s*. 6*d*. net.

THE publication of this memoir has been anticipated with much interest by all those concerned with the geology of iron-ores, since it contains an account of what are under modern conditions by far the most important producing areas in this country. Of late years the Jurassic system has been responsible for almost exactly 80 per cent of the total output of iron-ore in this country, a state of affairs which is mainly due to the recent developments in the manufacture of basic steel from phosphoric ores. This is precisely the same economic factor as led to the great prosperity of the German steel industry, which was almost entirely based on the phosphoric ores of Lorraine. During the War the production of basic steel in England showed a steady increase, although the total production of iron-ore even fell off a little. The great demand for

steel for munition purposes led to a great expansion of iron-mining, especially in the midland counties, the largest producers being the Frodingham district in North Lincolnshire, the Marlstone ores of the Banbury region, and the Northamptonshire ironstone of the Inferior Oolite. All of these are quarried almost exclusively in open-cast workings, and the general introduction of mechanical operation did much to counteract the labour difficulties that so greatly hampered the underground mining in Cleveland. By an elaborate and effective system of control, the Ministry of Munitions were able to arrange for the regular delivery at the furnaces of mixtures of ore from different sources adapted to the production of the types of iron and steel most required at the time. The history of this organization has been admirably written by Dr. Hatch in a publication reviewed in these columns some months ago.

The memoir now under review contains a very detailed and remarkably clear account of the geological relations and character of the deposits found in each district, containing a summary of all the information available, with abundant references to the earlier literature and illustrated by a great number of analyses or ores, both of ancient and modern date. There are also many tables of production and estimates of reserves. Not only are the actual workings now in operation described, but much information is included as to areas where ironstone was formerly worked and occurrences of ironstone, not hitherto exploited, which may be of value in the future. It must be confessed that the latter class do not seem to be of much promise, at any rate, until a very radical change takes place in economic conditions.

With regard to the interesting question of the origin of oolitic ironstones not very much is said, but the authors, as well as Sir A. Strahan in the preface, seem to incline towards the replacement theory. This is a difficult subject, and cannot be discussed here, but the detailed and careful work of A. O. Hayes on the Wabana Iron-ore of Newfoundland, and that of other American authors, seems to bring forward a good case for the primary origin of, at any rate, the green oolitic ores rich in silicates of iron. It is, however, very difficult to see how a rich and varied fauna of ordinary marine type managed to flourish in a ferruginous solution strong enough to lead to direct precipitation of ferrous silicates, which must almost of necessity require reducing conditions and absence of free oxygen. In this regard the large shells of *Cardinia* covered with a layer of green silicate found in the lower part of the Frodingham ironstone are of much interest.

We congratulate the late director and the officers of the Geological Survey on the completion of this exceedingly valuable series of monographs on the iron-ore resources of this country.

R. H. R.

BIBLIOTHECA CHEMICO-MATHEMATICA. CATALOGUE OF WORKS IN MANY TONGUES ON EXACT AND APPLIED SCIENCE. Two Volumes. Sotheran, 1921. £3 3*s*.

THIS work is the result of fourteen years' labour. It is probably the finest historical catalogue of science published in any country, containing, as it does, over 17,000 items, with current prices, bibliographical particulars, and many biographical and historical references. The reproductions of old illustrations, of which there are 127, are particularly fascinating, especially those of early ideas for steam engines, methods for "perpetuum mobile", etc.

It is certainly a work which should be found in every scientific and reference library.

THE ORE DEPOSITS OF UTAH. By B. S. BUTLER, G. F. LOUGHLIN, V. C. HEIKES, and others. Professional Paper 111, U.S. Geol. Survey. pp. 672, with 57 plates and 74 text-figures. 1920.

FROM the vast mass of geological literature, with an economic bearing, issued by the United States Survey, it is difficult and somewhat invidious to select individual publications for detailed notice. Nevertheless, no excuse is required for drawing the attention of British geologists to the admirable summary of the geology of Utah provided in the first hundred pages of this memoir. This State must always be classical ground in the history of physiographical and structural geology, and may be regarded as the typical example of its class; likewise it has been exhaustively studied by so many famous geologists, of whom we shall only mention G. K. Gilbert, whose memoir on the Geology of the Henry Mountains is fundamental on the physiographic and structural sides of the science. It is, therefore, highly valuable to have in a condensed form the results of these earlier labours as illuminated by more recent investigations.

The remaining, and by far the larger, part of the memoir is occupied by a detailed account of the economic products of the State, with a detailed description of the geology of each mining area.

THE LIMESTONE RESOURCES OF THE UNION. Vol. II: THE LIMESTONES OF NATAL, CAPE AND ORANGE FREE STATE PROVINCES. By W. WYBERGH, Geological Survey of the Union of South Africa. pp. 149, with 2 figures. 1920.

THE first part of this publication was reviewed in the GEOLOGICAL MAGAZINE, 1918, p. 522. The present and concluding part gives a full and detailed description of all the known occurrences of calcareous rocks likely to be of commercial importance in the three southern provinces of the Union, except the dolomitic marbles of Port Shepstone, which were fully described in the earlier volume. Except for this occurrence, Natal is sparingly supplied with limestones,

and little exploitation has been done. On the other hand, calcareous deposits of many kinds are widely distributed in the Cape Province, except in the extreme east. They are of many ages, ranging from pre-Cambrian to Tertiary and Recent, and therefore comprise many different types. They are, however, not abundant in the widely spread Cape and Karroo systems. The Orange Free State possesses abundant resources, especially of surface limestones, an extremely interesting rock type which is widely spread in South Africa, appearing to be due to evaporation of calcareous solutions ascending by capillarity from lime-bearing rocks undergoing decomposition below ground. Its origin is therefore analogous to that of the still more remarkable surface quartzites of that country.

The work of compiling this memoir has been carried out with great care, and it contains a large amount of valuable and interesting information.

AGRICULTURAL GEOLOGY. By F. V. EMERSON, Ph.D. pp. xviii + 319, with 270 figures. New York: John Wiley & Sons, Inc.; London: Chapman & Hall, Ltd. 1920. Price 16*s.* 6*d.* net.

THE late Professor Emerson, whose untimely death is much lamented, was Professor of Geology at the Louisiana State University, and also in charge of the geological side of the work of the State Experiment Station. This book is the fruit of his experience in teaching geology to agricultural students. It begins with the general characters of minerals and rocks, then passes on to the detailed consideration of weathering in all its forms, the action of water in erosion, transport, and deposition, and alluvial deposits, with a very full account of glaciation and the formation of lakes. The characters of coastal plains are discussed, while the final chapters deal with mineral fertilizers, the soil regions of the United States and historical geology; the last is compressed into less than six pages, and might well have been omitted, as the value of so brief a sketch as this is problematical. As might be expected, the treatment of the subject is distinctively American, hardly any reference being found to types of soil outside of the United States, although very brief accounts are given of the Stassfurt potash deposits and of the Chilean nitrate of soda. The middle chapters of the book, quite apart from their value as a treatise on the origin of the soil, form a very interesting small textbook of American physical geology, and they are illustrated by a large number of good figures, many of which, however, are reproduced on too small a scale to be as effective as they deserve. The processes of conversion of rock into soil are well described and illustrated by some very well-contrived diagrams.

SKÅNES DALMANITESSKIFFER. EN STRANDBILDNING. By G. TROEDSSON. Geol. Fören. Forh., vol. xlii, 1920. pp. 265–90.

THE *Dalmanites* shales of Scania, formerly called the Brachiopod shales, are the local representative of the Ashgillian series. The chief object of this memoir is to show that they belong to a

shallow-water type, laid down near the coast-line of the old Swedish highlands, this coast-line being approximately determined by an ancient north-west–south-east fault-system. The middle part of the sandy shales always includes one or two beds containing comparatively large quartz-grains and occasionally rounded pebbles of sandstone up to 10 mm. in diameter. Pyrites, phosphorite, and calcareous layers are common, the two first especially in the coarser portions. An abnormal occurrence at Röstånga is of much interest, since here there is repetition of the series, the upper sequence being of much more shallow-water character than the lower; that is, a shallow-water facies has been thrust over strata of a deeper-water facies. This the author attributes to submarine land-slipping, which, he says, is a frequent cause of the occurrence of contorted layers, interbedded with horizontally bedded ones. He estimates that this process is possible with a slope of the sea-floor as low as 4 to 6 degrees. This striking conception is somewhat inadequately treated in the German summary. The full text describes the formation of a peculiar breccia or conglomerate due to the slipping.

On account of the marked decrease in the depth of the water at the beginning of this stage, the old fauna almost completely disappeared, and only a few new forms came in. The presence of *Climacograptus normalis* serves to correlate the beds with British strata, but, on the whole, the fauna is mainly endemic. The presence of numerous ostracods and thin-shelled lamellibranchs suggests lagoon conditions.

REPORTS AND PROCEEDINGS.

Mineralogical Society.

March 22.—Dr. A. E. H. Tutton, F.R.S., in the chair.

Professor H. Hilton: "On the Vibrations of a Crystalline Medium." The paper attempts to give an indication of the kind of vibrations which the molecules of a crystal may be expected to make about their positions of equilibrium. The case of an orthorhombic crystal in the form of a rectangular parallelepiped is considered in detail, and the normal modes of the molecular motion completely determined.

Professor R. Ōhashi: "Augite from Nishigatake, Japan." The crystals have been detached from basalt by natural weathering. Sp. gr. is 3·338 at 4° C. The prism angle agrees with that of diopside but that of the pyramid does not. Etched figures show that the crystal belongs to the holosymmetric class. $a = 1{\cdot}6859$, $\beta = 1{\cdot}6917$, $\gamma = 1{\cdot}7105$, $2v = 58°\ 25'$. Extinction angle on (010) = 41·6°. The chemical composition is SiO_2 51·37, Al_2O_3 5·24, Fe_2O_3 2·02, FeO 2·96, CaO 21·58, MgO 16·94, TiO_2 0·58. Both the optical

properties and chemical composition show that in this augite the diopside molecule predominates.

Dr. G. T. Prior: "On the Chemical Composition of the Adare and Ensisheim Meteorites." Determination of the amount and composition of the nickeliferous iron in these meteorites had shown that Adare contained 18 per cent in which Fe : Ni = 11, and Ensisheim 3 in which Fe : Ni = $3\frac{1}{2}$. Analyses were made of the unattracted material in order to determine how far they supported the idea that in meteoric stones the ratio of MgO to FeO in the magnesium silicates varied directly with the ratio of Fe to Ni in the nickel-iron. The results showed that the ratios of MgO to FeO in the olivine and pyroxene respectively were about 4 and 5 for Adare and $2\frac{1}{2}$ and 3 for Ensisheim.

Mr. W. Barlow exhibited models to represent the atomic structure of calcite and aragonite.

Edinburgh Geological Society.

February 16, 1921.—Mr. E. B. Bailey, M.C., B.A., F.G.S., F.R.S.E., President, in the chair.

1. "Recent Contributions to the Geology of Spitsbergen." By Dr. Robert Campbell, F.G.S.

After indicating the nature of the pioneer work done during the nineteenth century, Dr. Campbell outlined the results arrived at by Nathorst in his monograph on the geology of Bear Island, Spitsbergen, and King Karl's Land, published in 1910. During the past decade notable advances, he said, had been made in our knowledge of Spitsbergen geology, particularly by Hoel and Holtedahl. It had been known that the "Archæan" of the north-west belonged to the Heclahook system. A strong case had been made, too, for regarding the Heclahook series as of Cambrian-Ordovician age, similar rocks in Bear Island having yielded a fauna of American facies resembling that found in the Durness limestones of North-western Scotland and in the Beekmantown limestone of North America. The Red Bay series of the North coast had yielded fossils suggestive of Downtonian age, and the remainder of the Devonian had been divided into three groups, comparable with the Caledonian, Orcadian, and Upper Old Red Sandstone of Scotland. They have yielded the same characteristic fishes, but, unlike their Scottish equivalents, they carried also, according to Holtedahl, several forms of marine lamellibranchs. The Carboniferous rocks were of interest because of the occurrence of coal seams in the Culm, and had been mapped in considerable detail by the geologists of various Norwegian, Swedish, and Scottish expeditions. Much new information of stratigraphical and palæontological value had been obtained. It had been established that great overthrusting movements had taken place—probably in Tertiary times—along the line of the fault that separated the Heclahook rocks of the west coast from the younger rocks to

the east. Of much interest, too, was the discovery at Bock Bay of a volcano, which had been active during the great Ice Age, and the occurrence of numerous hot springs, which had built up beautiful basins of carbonate of lime.

2. "Exhibition of Specimens and Fossils from Lowe Sound and Axel Island." By H. M. Cadell, B.Sc., F.R.S.E., J.P., D.L., of Grange, Linlithgow.

Liverpool Geological Society.

March 8, 1921.—W. T. Walker, Esq., B.Sc., F.G.S., President, in the chair.

The following paper was read: "Notes on the Geology of Lingdale." By F. T. Maidwell, F.G.S.

Lingdale was defined as the western slope of a wide, shallow valley-head, ranging from the high ground between the Uplands and the southern end of Bidston Hill in a north-easterly direction to the western side of Birkenhead Park. Many small exposures of what is presumably Lower Keuper Sandstone occur in the road-sides and lanes, as well as in the old quarries at Flaybrick Hill. The dip of the rocks is generally to the north-east, but the district is much cut up by faults ranging chiefly north and south, although there are some east and west faults which change the direction and amount of the dip, and bring in the Waterstones to the south of Howbeck Road. Detailed descriptions and measurements were given of the succession of strata in two instructive sections, where the junction of Yellow Upper Bunter Sandstone and the Keuper Basement beds is displayed.

Cornish Institute of Engineers.

April 2, 1921.

"Ore Deposits of Igneous Origin." By R. H. Rastall, Sc.D., M.Inst.M.M., F.G.S.

Ore deposits of igneous origin can be divided into two main groups: those associated with acid intrusions usually take the form of veins or lodes. They belong to the latest phases of cooling and tend to concentrate in the upper parts of the intrusive masses; furthermore, they commonly accompany pneumatolytic phenomena. The ore-bodies associated with the basic rocks, on the other hand, usually separate at an early stage, the intrusion often splitting into two immiscible liquid phases, as shown by Vogt in the case of the sulphides. The metalliferous phase, being the heavier, sinks to the bottom, although, owing to imperfect equilibrium and viscosity, this sinking is often incomplete and segregations of ore may be found at any level. An unusual type is afforded by the magmatic iron ores of Swedish Lapland, where concentration has been effected by sinking in an acid intrusion. The association of chromite and

platinum is characteristic of ultrabasic rocks. In the basic intrusions there is little or no vein-formation, the ore-bodies being basal or marginal, sometimes disseminated more or less uniformly, and pneumatolysis plays little or no part in ore-formation.

GEOLOGISTS' ASSOCIATION.

Friday, April 8, 1921.

"The Influence of Geology and Topography on the Growth of London." By C. E. N. Bromehead, B.A., F.G.S.

A new geological map of London, showing the "buried streams", with short accounts of the streams. The site of London, with reasons for its selection. Roman London. The site of Westminster, at the first ford. The Roman Roads round London. The growth of London and Westminster and the connecting link along the "Strand". To the end of mediaeval times the necessity for a defensible position limited the growth. The great expansion in the seventeenth century brought to an end by the question of water supply. The supply from the terrace-gravels and the means taken to supplement it. Growth ceases until beginning of nineteenth century. A few of the ways in which Geology affects London to-day.

CORRESPONDENCE.

GEOLOGY OF THE NINGI HILLS.

SIR,—As Major Williams in his letter in the February number handsomely disclaims all intention of being controversial, I am content to leave the matter where it now stands. My attitude towards the larger questions which Major Williams has raised will be made clear in a forthcoming publication of the Geological Survey of Nigeria, and I need not, therefore, transgress upon your space. May I say, however, that I have no recollection of ever stating—and certainly not in my last letter—that tinstone is or can be found only in the younger granites. That is quite a different matter from the question of its origin.

J. D. FALCONER.

JOS, NIGERIA, N.P.
5th March, 1921.

"LISSONS."

SIR,—Mr. Upton's explanation of the continuous rise of air from "lissons", quoted in the article under the above head by Mr. L. Richardson in the March number of the GEOLOGICAL MAGAZINE, does not appear quite satisfactory. Surely the barometric pressure into the ground would be able to act more readily in a downward direction through the fissures than through the interstices of the country rock.

The following alternative explanation is suggested. The normal temperature lapse rate in the lower layers of the atmosphere is − 1° F. per 300 feet, whilst the adiabatic lapse rate is − 1° F. per 172 feet. When the lapse rate in the atmosphere exceeds the latter quantity, a condition of unstable equilibrium ensues, and convection immediately sets in to restore equilibrium. Now, assuming the temperature gradient in the Oolites at Stroud to be − 1° F. per 60 feet measured in the same direction as that of the atmosphere, i.e. in an upward direction; and further assuming that the air in a fissure remains sufficiently long in contact with the country rock to take up its temperature (a period of a few minutes would suffice), it would appear that the column of air in the fissure would be in an exceedingly unstable condition and would at once tend to rise to the surface. This effect should be most noticeable during the winter, when no inversion in the lapse rate is likely to occur in the subsoil, as is the case in the summer.

No doubt the barometric tendency materially affects the velocity of the current—a negative tendency (i.e. when pressure is decreasing) should cause an increase; by analogy with the effect produced on fire-damp evolution in coal mines on such occasions.

The velocity of the current might temporarily be increased during the winter season by the rise in the level of the water-table subsequent to heavy rains, causing the upward displacement of air.

Norman L. Silvester.

Bedford College, Regent's Park, N.W.
April, 1921.

CORRELATION OF THE MEADFOOT AND SIEGENIAN BEDS.

Sir,—I read with interest in the April number of the Geological Magazine Dr. E. Asselberghs' remarks on the above subject. On p. 167 he says:—

"Later, other fossiliferous localities were discovered. Several lists of fossils have been published, but a great number of the identifications, based only on the already old descriptions of Phillips and Davidson, are doubtful."

He then quotes from a list of mine (Geol. Mag., 1909, pp. 133–4) as an instance. I should like to say I did not venture to identify any of the fossils given in my list. I submitted them first to Upfield Green (who was working with me at the time) and afterwards to W. A. E. Ussher. They were carefully examined by both, as was my list before publication. I gather from subsequent remarks that Dr. Asselberghs has confidence in the opinion of these authorities. Referring to the Devonian rocks of North Devon, Dr. Asselberghs says: "The stratigraphical succession is less known than in the South." I was not aware of this.

J. G. Hamling.

The Close, Barnstaple.

THE GLACIATION OF IRELAND.

Sir,—The discrepancies between the directions of ice movements shown in Professor Kendall's enlargement of Mr. Wright's map, and in that by myself (*Phil. Trans.*, vol. 210 B, p. 143) are due in the case of the four arrows across the Shannon Valley, near Lough Derg, to Professor Kendall having trusted simply to orientation, whereas my arrows were drawn in regard to the topography on Mr. Wright's map. For example, Mr. Wright's southern arrow across Lough Derg continues up the Nenagh Valley to the south of the river and ends there; so does mine; whereas Professor Kendall's is continued right across the mountain Slieve Kimalto. Mr. Wright's next line crosses Lough Derg further north and bends round into the valley of the Nenagh and reaches it at the bend, where it is joined by the Ollatrim; and I ended it there to avoid carrying it into the upper Nenagh. The northernmost of the four lines begins on the lower Bunowen River and crosses the Shannon at its confluence with the Little Brosna. My line passes through both points, but omitted the further continuation, that being less clear and not affecting its relations to the Eskers.

The glaring discrepancy in the north-western corner of Professor Kendall's map, near Clew Bay, is due to its omission of one set of Mr. Wright's lines. Mr. Wright's map shows two movements in Mayo crossing one another at or nearly at right angles. Professor Kendall has left out one series, thereby suggesting that the two arrows on my map showing a northward flow were inserted by mistake. I would ask anyone interested to compare Professor Kendall's enlargement with Mr. Wright's original map (*Quaternary Ice Age*, 1914, p. 49). Professor Kendall's photographic apparatus has powers of selection which merit the censure expressed in the last paragraph of his letter.

J. W. Gregory.

THE STADDON GRITS.

Sir,—I was much interested in the communication to your April issue by Dr. Asselberghs on the correlation between the Meadfoots of Devonshire and the Siegenian of the Ardennes, which forms an important contribution to our knowledge of the subject. He, however, unintentionally I am sure, misrepresents me in suggesting that I have referred all the beds usually included in the Staddon Grits to the *Cultrijugatus* zone. As a matter of fact, I expressly state (*Hand. d. reg. Geol., British Isles*, 1917, p. 106, note) that rocks lithologically similar to the Staddon Grits contain Meadfoot fossils. I also emphasize the fact that the Meadfoot Beds include a number of horizons. The truth is that an immense amount of work remains to be done on the zoning of the Devonian, both in North and South Devon and in Cornwall, and, if Dr. Asselberghs' contribution induces some of our local workers to take this up, it